FORESTS versus LIVESTOCK: AN ECONOMIC ASSESSMENT OF CHOICES FACING LANDOWNERS IN THE BOLIVIAN LOWLANDS

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Forests versus Livestock: An Economic Assessment of Choices Facing Landowners in the Bolivian Lowlands

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SECTION I
PROBLEM STATEMENT AND OBJECTIVES

A. The Cattle-forestry Conflict in Latin America

For the past two decades there has been extensive debate on the destructive interaction between cattle production and tropical forests in Latin America. The primary concern has been deforestation to provide land for pasture and cattle production. The literature has focused, with good reason, on two geographic regions: Central America, where the concern was that forest were being destroyed to produce cheap beef for the US market[1]; and Brazil, where vast areas of the Amazon were opened up for cattle production.

The increase of land allocated to cattle production at the expense of natural forests is the result of several interactive factors[2] which include: land tenure policies (Jones); extensive cattle production systems (Serrao and Toledo 1992, 1993); low timber values (Kishor and Constantino 1993); production characteristics of cattle (Hecht); favorable cattle markets and prices (Meyers 1981, Nations and Komer 1983); and government subsidies for livestock credit and road construction (Mahar 1988, Binswanger 1991).

More recently the debate has been widened to include other countries in South America. Questions abound related to the amount of tropical forest that should be preserved and the kinds of government interventions that could lead to decreasing rates of deforestation. This study is intended to contribute to this policy dialogue by identifying the incentives that might influence decisions of private landowners toward managing tropical forests in the lowlands of Bolivia, versus the primary alternative of converting lands to pasture for production of beef cattle.

B. Causes of Deforestation in the Tropics

Deforestation is often attributed to low returns from tropical forestry associated with the extractive nature of lumber industry, causing the reduction of residual value of forests and the eventual conversion of forest land to other sometimes unsustainable uses. The forest industry in Bolivia has been typified as extractive, focused on the export of products such as sawnwood of a few high value species, notably mahogany. Because of the selectivity and limited utilization of timber, logging pressure has been modest, but at the same time the value of forests has been very low. Some authors predict an increase in logging as markets become more accessible to the timber industry. Grainger, for instance, foresees a strong shift in tropical timber extraction from South East Asia and Africa to South America with the temptation for these newly favored

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1 The term Ahamburger connection@ was coined by Meyers (1981) to describe this phenomenon.

2 The list is taken from Godoy and Brokaw (1994) cited in Kaimowitz (1996).

producing countries to follow the downhill path of resource mining which has been pursued by many of their predecessors.

However the larger threat to tropical forests throughout the world has not been over harvesting, but conversion to other uses. Underutilization of the forest can be just as detrimental, in that private landowners perceive few benefits from managing the forest and see more possibilities by converting to other uses, such as livestock.

Contrasted to Asia and Africa where shifting cultivation is the largest contributor to deforestation, pastures for extensive cattle raising is the primary contributor in Central and South America. Conversion of land use in Brazil, for instance, has been carried out for multiple purposes, of which the most extensive is cattle ranching, as seen in the table below.

Table I-1. Purposes of Land Conversion in Brazil

Land Use	Percent
pastures	40
annual crops	32
shifting cultivation	13
permanent crops	4
hydroelectric power	4
mining	3
charcoal production	2
residual	2

Source: International Institute for Environment and Development

Rates of deforestation in Bolivia are subject to debate over different data sources and interpretations. The most reliable estimates suggest less than 200,000 hectares per year between 1975 and 1993, but is also clear that the rate increased dramatically during the 1990s. (Hunnisett) Although substantial, this translates into a deforestation rate of less than **2** percent per year, which is still modest compared to other world regions.

Probably most land clearing in Bolivia has been for agricultural purposes, rather than livestock, including small scale subsistence farming and also medium and large scale commercial farming. The majority of land cleared up to this point has been in areas appropriate for conversion to intensive cultivation. It seems likely, however, that the massive conversion for both agriculture and livestock purposes could extend into more fragile areas in the future.

Concerns over the increasing rate of deforestation and the depletion of valuable species led to a serious reconsideration of forest policy in Bolivia, culminating in legislation which require sustainable management by concessionaires and also forest landowners. These policies are being successfully applied to forest concessions where lumber companies are taking responsibility for sustainable forest management. However, under the new regime established by the 1996 Forestry Law, forest concessions on public lands have diminished to only about six million hectares, compared to more than 20 million earlier. A confusing land tenure system makes it impossible to know the amount of public lands remaining that could be bid out as new concessions. It is possible that claims of private individuals and indigenous groups could prevent additional concessions from being granted. Under this scenario, most productive forest in the country would be found on private properties, including indigenous lands.

C. Objective

The current study deals with productive forests on private lands which are designated in regional land use plans as being appropriate for timber production, but also are adaptable to extensive grazing for raising beef cattle. The objective of the study is to determine under what circumstances landowners would become interested in managing productive forest rather than converting all land to pasture for cattle.

The model explores limited policy options that might influence the landowner=s decision to sustainably manage natural forests for timber production. It is assumed that primary motivation of landowners will be to generate wealth from the resource base through productive enterprise. Besides clearing the forest, it is hoped than landowners might find it in their best interest to place forests under sustainable management for timber production.

D. Importance of the Study

Of the 55 million or so hectares of forest in Bolivia, it is estimated that the potentially productive forests may be between 12 to 16 million hectares. (Mancilla, 1996 and ITTO, 1996, respectively) Forest management through concessions and industry applied to public lands may address less than half the productive forest lands in Bolivia.

The Forest Superintendency of the Bolivian Government is already overtaxed with the regulation of less than 100 lumber companies with formal concessions and management plans on six million hectares. Regulation of tens of thousands of medium and small parcels on an additional 6 to 10 million hectares escapes realism, unless landowners find it in their own self interest to maintain the forest and apply management principles in compliance with local regulations.

If sustainable forest management practices are to be applied over the majority of Bolivian productive forests, the concept of the Apermanent forest estate@ will need to be extended to areas outside of supervised concessions where the local population uses the forest for its livelihood. The new Forestry Law takes the first steps by recognizing the rights of the population that utilizes forest products. It is not clear what additional measures may be needed to prevent massive conversion of forested land to other uses, particularly cattle ranching.

SECTION II
AGRICULTURE AND FORESTRY POLICIES AFFECTING LAND USE

A. Agricultural and Forestry Policies Before 1996

A1. Agricultural Land Tenure

The revolutionary political changes of 1952 in Bolivia brought massive reform of agricultural land tenure in the highland and valley regions. Land held in *haciendas* was broken into small parcels and distributed to peasant farmers, transforming the land-use pattern to an agricultural sector based on *minifundio.* Land reform had little relevance, however, in the lowlands of Bolivia. At the height of the agrarian reform, virtually the only area in the tropical lowlands with any appreciable population was the immediate agricultural area just north of the city of Santa Cruz. Land was not scarce in the lowlands, but merely inaccessible. Even the significant changes following the completion of the road from Santa Cruz to Cochabamba in 1956 were primarily limited to the area surrounding Santa Cruz.

Government policies beginning in the 1960s encouraged migration of indigenous people from the highlands and valley regions to the eastern lowlands. The incentive was large tracts of productive land available for those who chose to resettle. Initially, response was poor, mostly due to the lack of infrastructure which made trade outside the region uneconomical. But gradually both planned and spontaneous colonization programs have taken hold. Besides the eastern lowlands of Santa Cruz, similar colonization efforts reached from La Paz north into the lowland region called the Alto Beni and from Cochabamba north into the tropical lowland region known as the Chapare. Parallel to the colonization programs in Santa Cruz, the agricultural Afrontier@ expanded to large proportions with growth of medium and large scale farming enterprises on an area of perhaps a million hectares. As land has taken on market values, tenure has only now become conflictive within and among groups such as subsistence farmers, medium and large scale farming and livestock operations, logging interests, and indigenous groups.[1] In fact, the present picture is one of an unmanaged land rush, where the beneficiaries are often mid to large scale farmers/businessmen.

With no clear geographical references on titles and no cadastral system, plus a title registry system indexed by owner rather than by physical land parcel, the inevitable result has become a confusion of overlapping claims based on conflicting documents, often without regard to local occupancy. It is estimated that almost 95 percent of agricultural land in Santa Cruz, for instance, has improper title.

[1] Mining and petroleum rights continue to be administered through public concessions, as mineral rights belong exclusively to the state, with no benefit accruing to the landowner.

A2. Forestry Law of 1974

With the passage of the first forest legislation in 1974, formal use of the forest resource has been administered through forest contracts, similar to concessions. To be granted a contract or concession permit, applicants had to delineate an area not previously claimed, show sufficient funding for investment in processing facilities, generate a management plan, and begin harvest. Concessionaires had the right to harvest the timber as described in their management plan. They did not own the land or indeed have rights to use it in any other productive alternative. The longest term of a concessions was for only 20 years.

Concession contracts were given over public and private lands alike, largely without consideration to local occupants that may have traditionally utilized the forest resource, including indigenous groups. Besides concessionaires, hundreds of independent sawmills continued to operate, purchasing logs at the sawmill or hiring logging crews to harvest wherever timber could be found. Of course these independent loggers found themselves in conflict with concessionaires. Other problems were noted in this system, including overlapping claims and oversized concessions for land speculation purposes.

Numerous factors discouraged concessionaires from managing the resource, including the short duration of harvest rights in concessions. Other factors were related to large margins on sawnwood of a few high value species along with limited processing capabilities that would have allowed lumber companies to add value to other species. Lack of secure tenure over concessions certainly also discouraged operators from taking responsibility for sustainably managing the forest. Instead, sawmills concentrated on selectively logging the highest grade timber over extensive areas. Therefore, contrary to requirements in the law, virtually no sustainable forest management was practiced. The role of the national forest service was limited primarily to regulation of forest products, which unfortunately degenerated into revenue collection carried out through a large number of road checkpoints.

B. Reforms Introduced by the Land Tenure and Forestry Laws of 1996

The Government of Bolivia recognized the need to attract additional investment in rural areas and to provide incentives for resource management. This would require guaranteed property rights through clearly established institutional mandates and lines of authority over land titling and forest concessions.

B1. The Land Tenure Law (Ley INRA)

The Land Tenure Law of 1996 creates the National Agrarian Reform Institute (INRA) with sole authority over the land titling process in rural areas. The Law provides a space of 10 years to Asanitize@ existing rural land titles. Indigenous lands receive collective titles that cannot be bought or sold. INRA will also take steps to establish a cadastral system with precise geographical references and a title registration indexed by parcel of land, rather than by owner.

The Law retains the concept of reverting land to the State if its use fails to serve a social/economic function, but this concept is now expanded to include forestry and conservation--no longer only farming and grazing. Whereas before the land belonged to the person who used it--in practice meaning the person who cleared it for farming or livestock--now the land belongs to the person that pays the taxes on it. Under the reforms, if taxes have been paid during the previous two-years, it is assumed that the land is serving its highest socio-economic function.

The Land Tenure Law also establishes the regime for land distribution; guarantees land rights; and creates the Agrarian Superintendency and the Agrarian Judiciary. Unfortunately due to lack of funding and the huge task assigned to INRA and the other agrarian agencies, the impact of the Land Reform Law has as yet not been felt in most areas.

B2. The New Forestry Law

Under the new Forestry Law, the benefits of harvesting forest products now accrue to the landowner or concessionaire. In order to be harvested, forests must be managed under an approved sustainable forest management plan, which requires a forest inventory, definition of cutting cycle, details on regeneration, experimental plots to be measured at five-year intervals, logging practices to minimize damage, measures to protect waterways and wildlife, and such.

Harvest of forest products requires resource management under an approved sustainable forest management plan for each forest production unit, be it a concession, a tract of indigenous lands, or a private property. The only exception to this requirement is harvest during land clearing, which is approved under an individual property land use plan. (See below.)

Forest concessions are now awarded only on public lands. Private land ownership has priority over public concessions, and new concessions are given only through international bid. Other important changes in the forest law were that concession duration was lengthened to 40 years, renewable every five years, and concession rights can be traded. It is hoped that these changes to more secure tenure will induce greater investment in silviculture and improved forest management (as suggested by Zhang and Pearse 1996).

The Law creates the Forest Superintendency as an autonomous body in charge of overseeing the forest sector. Funding for the Forest Superintendency is ear-marked to come from the revenue collected on the area-based tax, thus tying the enforcement ability of the government to the area under forest management.

Another important initiative in the forest law is an effort to decentralize the control of forest use and management by incorporating local municipalities. Individual municipalities are to be awarded 20 percent of the public forest land within their jurisdiction to be maintained in forest production. In a recent study of the changing role of municipal governments and forest management in lowland Bolivia, Kaimowitz et al (1997) conclude, but not without reservations, that strengthening local government roles in forest management will be beneficial in natural resource management.

B3. Reforms in Land Taxation

Under the new regime, property taxes are established for grazing and forest land, plus a specific tax for land clearing. Ranch land incurs a progressive tax according to the total land value[2] declared by the owner on a progressive scale beginning at 0.35% and increasing to 1.50% of the value without improvements. (See Table II-1below.)

Table II-1 Land Tax Schedule for Livestock Ranches, 1996

Declared Total Value of Property From	To	Fixed tax	Plus variable rate	On amount over
-----------------------(USD)	----------------------		(%)	(USD)
0	40,856	0	0.35	0
40,856	81,712	143	0.50	40,856
81,712	122,569	347	1.00	81,712
122,569	higher	756	1.50	122,569

Source: FEGASACRUZ

Actual land prices for cleared pasture land may be as high as $500 per hectare in accessible areas along major roads in regions such as the Chiquitanía of Santa Cruz. Prices decrease dramatically outside these zones, and drop to $20 or even lower for uncleared land without title towards the Brazilian border. Generally, pasture lands with limited access may be valued between $100 to $250 per hectare. Depending on the size of ranches and the total value, taxes on land cleared and planted to pasture are typically between $0.20 and $0.50 per hectare.

Another important component of the reforms is the change in forest taxation methods. Previously a volume-based tax on timber extraction, the taxation system is now an area based tax. Theory suggests that in even-aged forest management, area-based taxes reduce the rotation length in forestry production, whereas volume or yield-based taxes lengthen the rotation. The equivalent in tropical forestry would be an increased intensity of management or extraction per hectare with an area-based tax to cover the fixed annual outlay. Although not theoretically as efficient at rent capture as sealed bid concession allotment, or even the previous volume-based tax, the area-based tax system has an overwhelming advantage in its ease of enforcement (Hyde and Sedjo 1992), which was the overwhelming argument for its adoption by Bolivian authorities.

The impact of the area based tax became readily apparent because the dramatic decrease in the area under concession agreements from a previous 21 million hectares to about six million nationwide today. One interpretation of the massive reduction of concessions is that the present value expected from timber extraction is insufficient when compared to the annual area-based tax, which is set at a minimum of $1.00/hectare/year over the entire concession area. In fact a much lower tax of $0.40 was recommended by Hyde et al (1996) who based their

[2] Total land value is calculated (number of hectares * per hectare value).

recommendation on 10 percent of an estimated $US 4.00 per hectare annual stumpage value. Another reason for the reduction undoubtedly stems for the limited capital available in the lumber industry, which may be insufficient to effectively manage more than about six million hectares.

Private forest lands pay the same patent per hectare as concessions, but only over the area of annual allowable cut. In other words, private forests under management plans pay only one dollar per hectare on the area harvested, rather than the entire productive forest area. With a minimum cutting cycle of 20 years, forest landowners need only pay $1.00 for every 20th hectare, or an average of $0.05 per hectare of forest per year. With longer cutting cycles, the tax per hectare of forest is even lower.

Under the new law, land clearing is taxed on both area and volume of timber removed. The area tax or patent is currently set at 15 times the per hectare patent paid be forest concessions, or $15/hectare.[3] The volume tax is computed at 30 percent of the value of timber at the land clearing site, according to a price list established by the Forest Superintendency. The landowner pays 15 percent of the value and the buyer of the timber another 15 percent. The price list applied by the Forest Superintendency for 1998 seems to reflect international timber prices less extraction and milling costs, which are several times higher than the amounts paid by local sawmills. Therefore, timber will be extracted from land clearing sites only in cases where the landowner is able to find interested lumber industries with capacity and access to international markets. Otherwise, the timber will be burnt off, a practice common in the Bolivian lowlands.

B4. Land Use Planning Requirements

The current Forestry Law requires preparation of ALand Use Plans@ for individual properties to be prepared within the context of regional land use plans (locally referred to as PLUS) currently being developed for the lowlands of Bolivia. Land clearing is to be approved only according to individual land use plans.

Individual land use plans include the concept of ecological reserves in areas for windbreaks, close to streams, on steep slopes, in wetlands, on thin or rocky soils, etc. Land in these areas cannot be cleared of natural forests, and no forest harvesting activities can be carried out in these reserves. Individual land use plans also specify the uses that can be made of the land resource, classifying areas for intensive annual cropping, perennial crops, pastures, open grazing, and forestry. The plans prescribe minimum conservation practices to be required of the owner/operator. Individual property land use plans are to be registered with land titles and become legal zoning restrictions or easements applying to current and future owners.

[3] The forest concession patent was initially set at $1 per hectare. It can be adjusted upward in future years with changes in international tropical timber prices, but can never be lower than $1/hectare.

Just as with sustainable forest management plans, individual property land use plans are prepared by professionals hired by landowners, but who are legally responsible for the veracity of the information and analyses to the Agrarian and Forest Superintendencies.

SECTION III
FORESTRY SECTOR: DESCRIPTION AND ISSUES

A. Overview

Approximately 51 percent of Bolivia's 1,100,000 square kilometers is covered in forest (López 1993). The tropical forest in Bolivia is located in the northern and eastern lowlands, comprising six identified forest ecozones. The e*vergreen lowland forest*, an extensive formation throughout northern Bolivia's Amazon region, is characterized by high rainfall. The *Yungas forest* is found in the humid mountain valleys of Andean range in the departments of Cochabamba and La Paz. The *sub-tropical humid forest* is the most important commercial zone, being characterized by a diverse forest with over 100 potential timber species. The *semi-humid low forest* is found mostly in the Chiquitanía region where rainfall is progressively lower to the east. The *semi-humid mountainous forest* extends south, is less productive, and reaches as high as 2000 meters above mean sea level. The *semi-arid low forest* is found in the Chaco region of the southeast. (López 1993).

Of the 55 million or so hectares of forest in Bolivia, it is estimated that the potentially productive forests may be between only 12 to 16 million hectares. (Mancilla, 1996 and ITTO, 1996, respectively) Extraction has depended heavily on selective logging of three basic species--mahogany (*Swietenia macrophylla*), roble (*Amburana cearensis*) and cedro (*Cedrela fissilis*). Under the recent reforms to establish sustainable forest management practices, there is a concerted effort to improve the per hectare value of forest land by encouraging the planned extraction and export of a wider variety of species, while allowing the forest time for regrowth and regeneration between logging cycles.

This chapter provides an overview of the forest sector and identifies some of factors that can be important to the landowner's decision to maintain and manage forest. It begins with a description of markets for Bolivian timber products and moves on to cover extraction, transport and milling costs. From there, lumber prices and stumpage values--both current and potential--are presented. Finally, the chapter discusses the issues, costs and benefits surrounding sustainable forest management. The statistical annex to this report contains additional information on the forests found in the specific sites used as reference in the study.

B. Bolivian Wood Products: Volumes, Markets and Values

Export markets are estimated to account for 70 percent of the total market value for Bolivian wood products. (Table III-1) The driving force for the past twenty years in the forestry sector has been the selective logging and export of mahogany. Now there is a genuine concern over the stock of mahogany in Bolivia, with estimates suggesting that there are as few as five years production remaining.

Table III-1 Markets for Bolivian Forest Products, 1995

Final market by type of product	Value in US$	Percent
Export of sawnwood	63,188,033	56
Export of semi-processed and processed wood products	15,617,689	14
Domestic markets	33,770,879	30
Total	**112,576,601**	**100**

Note: Percent totals may not add due to rounding.
Source: Pattie and Aguilar based on data reported by Cámara Forestal de Bolivia (CFB) and the Private University of Santa Cruz (UPSA)

Although the domestic market accounts for only 30 percent of the value of timber products, it accounts for higher volume than exports. With an annual cut of around 750,000 cubic meters of logs, a conversion rate to sawnwood of 50 percent, and volume of wood exports around 130,000 cubic meters per year, apparent consumption (annual cut less exports) would be about 240,000 cubic meters per year.

The above volume for the local market is considerably above most earlier estimates. In any event, the local market is small compared to supply. For instance, 240,000 cubic meters could be provided by land conversion at a modest 10 cubic meters per hectare in only 24,000 hectares per year. This is lower than most estimates of land cleared for agricultural purposes in Santa Cruz alone. It is apparent then, that most of the forest industry with concessions at some distance from processing and shipping centers are oriented primarily to exporting selected high value species, while the local market is supplied by smaller mills taking logs from other sources closer to market centers. Virtually the entire lumber industry in Cochabamba, for instance, is supplied from areas being cleared by small farmers.

The use of the forest resource in Bolivia has expanded rapidly in the past ten years, as reflected in the value of wood exports of $82 million in 1996, up from $49 million in 1990 (Table III-2). The largest value of timber harvested in Bolivia is exported as sawnwood, although processed wood products accounted for more than 20 percent of the value of timber product exports in 1996[1].

[1] Non-timber forest product exports, including Brazil Nut, heart of palm and rubber are not considered in this study. These products are important in the Northwestern portion of the country, particularly Pando.

Table III-2 Value of Lumber and Processed Wood Product Exports from Bolivia

Product Group	1990	1991	1992	1993	1994	1995	1996
	(millions of dollars)						
Sawnwood	36.4	41.6	41.2	44.5	70.8	63.2	64.6
Processed Products	12.5	7.4	8.8	8.8	18.6	15.6	17.8
Total	**48.9**	**49**	**50**	**53.3**	**89.4**	**78.8**	**82.4**

Note: Processed products include sleepers, veneer, plywood, flooring, moldings, and others.
Source: Pattie and Aguilar, based on data from the Cámara de Industria y Comercio and the Cámara Nacional Forestal

With the decline of mahogany stocks, there is now a concerted effort to improve the per hectare value of forest land by encouraging the extraction and export of lesser known species. To date, relatively few have been exported in any significant volume, with roble and cedro as two notable exceptions. Indeed, roble has overtaken mahogany in sawnwood export volume for 1994 with 35,000 cubic meters compared to mahogany at 30,000 cubic meters, however, the mahogany value remained greater at $14.3 million versus $10.9 for roble. The diversity of species now exported in the form of sawnwood has increased from only eight species in 1985 to 29 species in 1997. Despite the significant increase in export of some species, such as Yesquero (*Cariniana estrellensis*), the first three still accounted for 88 percent of the total volume.

C. Extraction and Milling

The steps and estimated costs of extraction are shown in the table below, according to a 1996 BOLFOR study based on a volume of 8,400 cubic meters in logs entering the sawmill. Even before felling of trees, however, under traditional methods where only selected species were used, sawmills paid teams of people to locate stands of valuable timber, operating over very large expanses of forest land. Under the new regime, planned harvesting in defined areas of annual allowable cut may result in reduced costs of logging operations similar to those shown below.

Table III-3 Average Costs of Extraction, Transport and Sawing into Lumber

Operation	Variable Cost	Fixed Cost	Average Cost
	(Dollars per m3 of logs entering mill)		
Felling	5.00	0.00	5.00
Skidding	5.74	6.06	11.80
Loading	2.51	2.47	4.98
Transport	9.98	1.75	11.73
Roads	9.30	7.23	16.53
Sawing into Lumber	19.91	6.55	26.46
Total	**52.44**	**24.06**	**76.50**

Source: BOLFOR, Rice and Howard, Doc Tec 32/1996, May 1996

Milling efficiency is generally thought to be around 50 percent. However, there is a difference among regions due to the incidence of new hardwoods which are coming into use. Industries are only now acquiring adequate equipment and the expertise in the use of these timbers. Also, initial estimates of standing timber often exceed those of felled logs because limitations such as hollow trees and other damage are identified after trees are cut. To illustrate the differences currently experienced, Table III-4 below depicts the relatively low rates of efficiency in the Chiquitanía compared to the Amazonía. Rates of conversion efficiency of hardwoods from the Chiquitanía are improving and are expected to approximate those of medium density woods in the future.

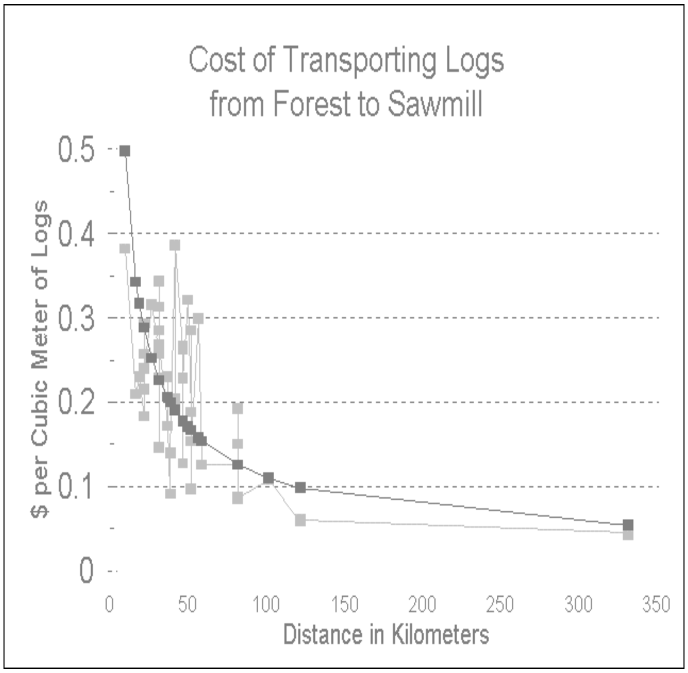
Table III-4 Approximate Milling Efficiencies by Region

Stage of Processing	Amazonía	Chiquitanía
	(percent of estimated volume)	
Estimated volume of standing timber	100	100
Volume of felled timber in logs	80	70
Sawn lumber	50	40
Resulting percent of standing timber volume	40	28
Expected percentage with increased efficiency	40	35

Source: Personal interview, Abraham Guillen, BOLFOR

D. Transport of Logs and Lumber

Logs are usually transported over relatively short distances to sawmills, especially in the case of lumber companies that can locate sawmills in or near concessions, allowing transport within only about 30 kilometers. General surveys of independent loggers and sawmill operators (Córdova) determined an average distance of 52 kilometers in 1997[2]. In a few cases, logs are transported much larger distances. Transport costs per kilometer decrease with distance, ranging from less than $0.10 for over 100 kilometers to over $0.20 for distances under 50 kilometers. (See figure.) The total cost of transporting a cubic meter of log 60 kilometers is estimated at $8.96/m3, while transporting a cubic meter 90 kilometers would cost $10.55/m3. Weight density of woods also has an impact on transport, with hardwoods costing perhaps 20 percent more per cubic meter than relatively less dense medium woods.



Lumber is transported from sawmills to local market and processing centers--mainly Santa Cruz, La Paz and Cochabamba--over distances between 300 to nearly 1400 kilometers. Transport is usually by truck, and from more remote regions in the northwest, by riverboat. Road infrastructure from sawmills to major cities in most areas consists mostly of dirt roads useable only during dry weather. Average cost of transport by truck is close to $0.065 per cubic meter of lumber for kilometer while the cost by riverboat is close to $0.028 per cubic meter-kilometer.

[2] Córdova, BOLFOR.

Final processing is nearly always carried out in one of the primary population centers. Here processing includes drying, precision cutting, and other manufacturing, such as for veneer and plywood. Local consumption is concentrated in these same centers as well. Species targeted for export are graded, with the highest grade being exported primarily to the United States and Europe through the Pacific port in Arica, Chile. This flow accounts for about 75 percent of wood exports, while 25 percent of Bolivian wood exports, dominated by second grade lumber, is channeled through Yacuiba on the southern border with Argentina. The remaining lumber of the select species is used locally for carpentry (largely doors and windows) and furniture manufacture.

The cost of transportation from Santa Cruz to the port at Arica is $74 per metric ton (CADEX) which translates into more than $59 per cubic meter or $0.14 per board foot[3]. If export transport costs both from the forest areas to processing centers within Bolivia and also through export corridors were significantly reduced, the impact in terms of the range of species that might become competitive in export markets could be significant.

E. Lumber and Stumpage Prices

As seen above, local markets are easily saturated, utilizing mainly third grade mahogany, and roble for doors, windows and furniture, plus a small but expanding number of species for construction lumber. Although more than 100 species are marketed today, many of them in very small quantities. The supply of timber from land clearing operations is more than the local market can absorb. In practice, if any timber is utilized from a particular land clearing site, only a handful of species might be involved.

In areas close to markets and with good access, sawmills might pay $5 to $10 per standing tree[4]. Farther from market centers, most landowners do not sell standing timber at the time the land is converted to other uses, but instead bulldoze or cut by chainsaw and burn the trees.

Log prices are usually quoted at the sawmill rather than the origin in the forest. Quotes range from $40 to as high as $200 per m3 for high quality mahogany (ITTO, 1996). A price of $60 per m3 barely covers cost of extraction and transport to the local sawmill. (A. Guillen, personal interview)

Many studies have expressed concern that throughout the tropics the low levels of log prices reflect a diverse array of underlying problems and market imperfections arising from

[3] Cámara Forestal de Bolivia export data for Santa Cruz (1996) show an average weight per cubic meter of 795 kilograms or 1.25 cubic meters per metric ton. There are about 424 board feet in a cubic meter.

[4] According to local sawmill operators and sector leaders.

inadequate numbers of potential buyers, restrictions on market entry, inefficient and/or inequitable log sales systems, insecurity of property rights, poorly informed sellers and lack of technical and market information about the species and their properties. (See for example Ferguson and Muñoz-Reyes)

Indeed it should come as no surprise that stumpage values are near zero. Rents from resources are attained only when rights are defined and access limited. (See Hyde, et al) If a landowner were to ask too much for his/her timber, the logger can simply move to another (unattended) site and take timber at no purchase price.

Therefore under current conditions, stumpage values in Bolivia are often very low or near zero, providing little incentive to dedicate any land with potential for other uses to productive forest. This situation in Bolivia may be changing as the new government forestry and land tenure policies take effect.

Potential stumpage values can be obtained by taking local price of sawnwood at the market center and working backward through the transport, milling and extraction. The resulting values for each species can then be applied to the existing volume of marketable timber per hectare found in different forests. A crucial factor in this calculation is the efficiency of logging and milling operations, including the amount of wastage. Table III-5 provides estimations based on transportation costs for the Chiquitanía region.

Table III-5 Potential Stumpage Prices for Managed Forest

	Lumber Prices		**Potential Stumpage Prices--Chiquitanía**	
	USD per bft of lumber	USD per m3 of lumber	USD per m3 of timber Medium Density	USD per m3 of timber High Density
High Value Species				
Morado	2.03	860.95	NA	183.80
Mara	1.16	491.30	131.07	NA
Roble	.86	365.06	80.58	NA
Cedro	.95	403.59	95.99	NA
Valuable Species	.81	345.16	72.61	39.38
Less Known Species	.58	243.91	32.12	11.03

Note: Weighted Averages, 70% export, 30% local prices
Source of export prices: Cámara Forestal de Bolivia
Source of local prices: BOLFOR studies by Soto and Córdova

Prices and conversion factors are conservative. Still potential prices are far greater than those currently paid by local sawmills. Mahogany, for example, could pay nearly $300 per tree rather than the $46 currently quoted. Most commercial species, could pay 80 to 150, rather than 10-15 typically paid today.

Therefore, it can be asserted that current prices understate the value of timber because 1) landowners still have limited control over the resource, 2) landowners may not be aware of market values, 3) export market potential is only recently becoming reality. The second set of figures may be more defensible, but perhaps not when applied over all marketable species from a particular site. That is, a small volume of a particular less known varieties such as Momoqui (*Caesalpinia pluviosa*) might be exported at a premium price, which does not imply that all Momoqui can automatically be valued at that level. Therefore, the values resulting from the higher price levels should be considered potential values.

F. Sustainable Management of Natural Forests

The ITTO objective 2000 states that all tropical timbers traded on international markets be derived from sustainably managed forests by the year 2000. Despite this initiative, precious little natural forest management is practiced throughout the world today. (Johnson et al) However, the Bolivian initiative goes even further, as shown in the previous section, as the Forestry Law requires that all timber harvesting must be carried out under approved management plans.

The very concept of sustainability, however, has been subject to much debate. Duncan Poore examines this issue under two headings: what product, and what condition? He points out that the most natural interpretation of sustainability from the point of view of the timber trade is the sustained production of specified timber products. However, environmental arguments are likely to concentrate more on the condition of the forest, and therefore on the proper designation of any particular forest in national policies for the allocation to different uses. AThus, if one is to be strictly accurate, sustainability can only be defined in relation to a specific set of products and a specified condition.@

Any commercial harvesting does deplete biodiversity to some extent. (Keto, et al) In fact, some authors assume that biodiversity is associated mainly with unmanaged forest--that is, forest not managed for timber production. (Von Amsberg) However, even the focus on sustainable timber production may lead into a trap. Some authors assert that the correct definition should be related to sustaining the forest against conversion. Sustainable management must therefore be competitive enough with other land uses such that the forests are conserved for the perceived benefits they provide. (Johnson, et al)

ASustainable wood production depends on: (1) prescribing and enforcing a basis for the amount of wood to be harvested per unit time such that an approximate balance can be achieved between future growth and the amount cut on a forest management unit, and (2) prescribing and enforcing the manner of harvesting and subsequent silvicultural measures to ensure adequate regeneration and/or release of sufficient smaller-sized stems from competition.@ (Ferguson and Muñoz-Reyes) Elements of management include: felling cycles, working plans, yield control and prediction, roads, boundaries, costings, annual records, and also organization of silvicultural work. Silvicultural work includes such aspects as: regulation of shade and canopy opening, treatment to promote valued individuals and species and to reduce unwanted trees, climber cutting, refining, enrichment, poisoning, selection. (Poore 1988)

Because so little forest management has been practiced up to now, the costs and benefits accruing to the landowner/operator are not well understood. The table below depicts the principal steps in the forest management process, and suggests that many of the costs are primarily fixed with respect to the size of the unit. If so, then the cost per hectare of managing large tracts of land, such as forest concessions of 50,000 hectares, can be expected to be much less than the cost per hectare of managing a private property of, say 5,000 or only 2,000 hectares.

Table III-6 Costs Involved in Sustainable Forest Management

Concept	Type of Cost
Establish the Forest Management Unit	fixed
Prepare Management Plan with Inventory	partly fixed
Demarcate Boundaries	fixed
Establish and Maintain Physical Control	fixed
Build and Maintain Roads and Drainage	variable
Contract Sales and Supervise Logging Practices	fixed
Maintain Records and Report	fixed
Pay Fees	variable

Benefits to the forest operator derived through applying sustainable forest management practices are also only recently being experienced. In the Bolivian lowlands, concessionaires cite the virtue that they are able to plan their operations, concentrating in a given area with a known stand, rather than spreading operations over expansive territories each year. A fundamental change in approach is the utilization of several species, rather than concentrating on only a few select species as in the past.

G. Forest Density and Productivity

Only now that the first forest management plans have been presented to the Forest Superintendency is forest inventory data available in Bolivia.[5] Forests vary greatly, sometimes even within relatively short distances. A sample of management plans taken over a wide area of the eastern lowlands show that estimated stands of trees over 20 centimeters diameter at breast height (DBH) average from about 20 to over 80 cubic meters per hectare over extensive managed areas. The range is even wider if the variations within areas is accounted for.

[5] Under Bolivian Law, forest management plans are open to inspection by the public.

Information regarding regeneration and regrowth is more difficult to ascertain. Using the management plans as a guide, forest operators intend to remove between 10 to 35 percent of the forest volume on a cycle of 20 to 35 years. Lower volumes would be cut in Amazonía, undoubtedly because of more selective harvesting for higher value timbers due to higher transport costs from the region. However, the cutting cycle in the Amazonía management plans is consistently shorter (20 years) because of anticipated faster growth rates. Higher volumes are planned to be removed from forests in the Chiquitanía, but with longer cutting cycles, reflected slower anticipated growth of hardwoods in those areas.

Average volumes per hectare per year to be removed from the forest range from 0.3 to 0.8 cubic meters per hectare per year, with the higher numbers corresponding to the Amazonía. In order to harvest these quantities, the overall growth of entire forest would be expected to be from 0.5 to about 2 cubic meters per year.

SECTION IV
CATTLE PRODUCTION IN THE BOLIVIAN LOWLANDS

From the extensive grasslands in Beni to the dry scrublands of the Chaco, cattle production has been part of the land use mosaic in the Bolivian lowlands for centuries, and will undoubtedly remain so into the foreseeable future. The current Bolivian cattle population is approximately six million head, up 9 percent from the 1990 population of 5.5 million. Of the six million head, 2.7 million can be found in Beni and 1.5 million in Santa Cruz.

Beef cattle ranching in Bolivia is extensive, characterized by low input and management costs. Stocking rates and production efficiency have been notoriously low, and there have been few technological changes until very recently. Although beset by problems, land in the Bolivian lowlands is suitable for cattle production--a fact confirmed by the land use plan for the extensive Santa Cruz Department, which shows 23.6 million hectares (64 percent), of a Department total of 37 million to be suitable for cattle production in one form or another.

A. Regions of Beef Production

The largest cattle producing region in Bolivia is the Beni, where livestock range on natural grasses subject to severe seasonal flooding in summer months (November through March) and to dry conditions prevailing in winter. Ranching in this region is extensive with low productivity indexes, but natural grazing conditions still permit cattle production at reasonable cost. Because of seasonal flooding, forest potential is absent in the heart of the Beni (surrounding the city of Trinidad), and therefore the region is not included in this study. To the east, lies the La Paz-Beni region connecting to the Alto Beni and on through a rugged mountainous area called the Yungas to the city of La Paz. Cattle are transported from the Beni plains through this region to market in La Paz, but little land has been cleared in the La Paz-Beni region for cattle production as of yet. Recently, Beni ranchers have established at least one abattoir in the region to permit transport of refrigerated beef sides, rather than live animals, a practice which has cut transportation costs in half.

To the distant north lies Pando, a Department which like the La Paz-Beni region is virtually all forested, having very little cattle production. In fact, Pando is supplied with beef from ranches in the northern areas of the Beni plains. Both regions have potential for forest production as well as agriculture and livestock uses. Different agencies in the Government have produced conflicting land use plans for Pando, one showing sustained forest production while another suggests impending conversion to agriculture and livestock.

The Department of Santa Cruz extends over one third of the country's entire territory, and lies at the center of the lowlands, ranging from humid areas to the north bordering the Beni to the dry Chaco in the south. The three principal regions of cattle production within Santa Cruz depict the variations found throughout the country. The first is the integrated or expansion zone surrounding the city of Santa Cruz where intensive beef cattle and dairy production is developing alongside a thriving agricultural industry based on sugar cane, rice, soybean, sunflower, sorghum, wheat and other field crops. About a third the Department's cattle population can be found here under relatively intensive management on improved grasses (Table IV-1). In many cases, land that was originally cleared for agricultural production has reverted to pasture. This land is accessible to the Santa Cruz market and is virtually all cleared for cultivation, however, it is relatively high price--a combination of attributes which encourages more intensive management. In recent years, it has become common to bring young steers into cultivated pastures near Santa Cruz for fattening before final sale, frequently at stocking rates up to two animals per hectare. It is expected that the trend toward cattle production, especially growing/fattening operations, will continue to expand in this area. Marginal agricultural land is available for productive establishment of pasture. In addition, the burgeoning urban market of Santa Cruz, now close to one million, will provide a substantial demand.

Table IV-1 Cattle Population in Santa Cruz by Province, 1992-1995

Province	1992	1993	1994	1995
		(head)		
Andrés Ibanéz	126,916	130,723	134,645	138,685
Warnes	68,403	70,455	72,569	74,746
Obispo Santiestevan	43,516	44,821	46,166	47,551
Sara	86,222	88,809	91,473	94,217
Ichilo	48,722	50,184	51,689	53,240
Florida	76,123	78,407	80,759	83,182
Vallegrande	108,386	111,638	114,987	118,436
J.M. Caballero	40,584	41,802	43,056	44,347
Cordillera	239,134	246,308	253,697	261,308
Chiquitos*	110,360	113,671	117,081	120,593
Ñuflo de Chavez*	117,686	121,217	124,853	128,599
Velasco*	151,568	156,115	160,798	165,622
Angel Sandoval*	181,532	186,978	192,587	198,365
Germán Busch*	53,158	54,753	56,395	58,087
Guarayos	39,335	40,515	41,731	42,982
Total	1,491,645	1,536,396	1,582,486	1,629,960

* Provinces which comprise the Brazilian Shield/area of study (41 % of total herd, 1995).
Source: CAO 1996

The second production region is the Chiquitanía which cuts a diagonal swath from top left to bottom right through eastern Santa Cruz. Designated as mostly joint, sustainable forest management and limited cattle production, this area holds 39 percent of the cattle population of Santa Cruz. Extensive ranching on wooded savannas characterizes cattle production in much of the area, and the interaction between forests and cattle has been underway for over two hundred years (Killeen 1991). Cattle production is increasing in this region, with the gradual clearing of forests by hand and sometimes using mechanized methods. Most soils are not apt for agricultural production, while infrastructure improvements have made the Santa Cruz market more accesible for cattle ranchers.

The final area of cattle production is the Chaco where production is practiced on an extensive scale, with as much as 15-20 hectares needed to maintain a single animal unit. This harsh, dry region holds approximately 20 percent of the Departmental herd, and much of this region is described in the Departmental land use plan as useful only for extensive cattle production, with some forestry. The Bolivian Chaco region continues further south through the Departments of Chuquisaca and Tarija to the borders with Paraguay and Argentina.

This chapter will illuminate some of the constraints and potential in the Bolivian cattle sector by addressing the following: markets and prices; production activities, timetable and budgets; and finally, grasses, land clearing and fencing.

B. Markets and prices

Limitations in the export markets are created by high transportation costs, and the continued incidence of hoof-and-mouth disease. Until a few years ago, much of the meat supply reaching the city of La Paz was transported by air from rustic slaughtering operations at ranches in the Beni. Cattle are still shipped by river in the Beni and then trucked to market in Cochabamba. Even transportation to the Santa Cruz market is difficult from many areas. The only three commercial abattoirs are located within the city of Santa Cruz, and therefore animals are transported live from connecting regions. Efforts to export to points east and south (Brazil and Argentina) are stymied by lower prices and higher product quality in those regions.

The second export constraint is hoof-and-mouth disease, which creates an export barrier to countries or areas free of this disease. There is an active campaign to eliminate hoof-and-mouth disease from certain areas in the Bolivian lowlands, but meanwhile the severe constraints on exports ensure that the domestic market for beef is of paramount importance to producers.

Local prices are cited in dollars per kilogram on the hook. Animals are usually grown out on ranches and are marketed at full size between three and four years of age at about 350 to 400 kilograms live weight. Although national consumption is very low--only about 18 kilograms per capita annually--average beef prices have risen to about $1.50 per kilogram at present. Little price differential is given for higher quality beef, such as from younger animals.

C. Production Activities, Timetable and Budgets

Production activity for cattle is aligned with the seasons. Calves are timed to be born in August, immediately before the rains, and to be weaned in April/May at 7-8 months old. All associated activity is based around this cycle. Table IV-2 shows the production timetable for the experimental ranch AEl Salvador@ located in the Chaco (Saravia et al. 1995).

Table IV-2 Schedule of Production Activities

Affliction and control action / **Month of**	J	F	M	A	M	J	J	A	S	O	N	D
Foot and Mouth--once/yr, all herd						■	■					
Rabies--once/yr, all herd								■				
Blood infections--all herd								■				
Gangrene--all herd								■				
Neonatal diarrhea--during birthing months									■	■	■	■
Brucelosis--all females 1-2 years old						■	■					
Internal (ecto) parasites--with injection					■					■	■	
External (endo) parasites--when necessary												
Control of Trichonomas, Leptospirosis, and Baloneprostitis--in bulls										■		
Mineral salts--during rainy season	■	■	■	■							■	■
Neumoenteritis--treat with alcohol at birth									■	■	■	■

Source: FEGASACRUZ: Manual de Ganadería del Chaco.

Within this timetable, strict attention should be paid to pest and disease management under the difficult conditions of the Bolivian lowlands. However, these practices are often neglected, to the detriment of production efficiency. The following, brief and general, descriptions of pest and diseases are those prevalent in the Bolivian Lowlands, and throughout much of Latin America.

At birth, calves should receive injections against endo/ecto parasites. Worming is then done about every three months thereafter until calves attain about 300 kilograms. Cows and bulls should be wormed every six months at the beginning and end of the rainy season. External parasites such as ticks, mosca del cuerno, and borboro *Dermatobia hormini* are controlled by spraying with insecticide. Regular rotation of pastures also helps in tick control. Calves should get three vaccines at three months old--against Black leg (gangrene), Malignant edoema, and Hemmoragic septiciema. Female calves receive and additional vaccine at 3-7 months against Brucelosis. All animals are vaccinated against rabies once a year and hoof-and-mouth disease once a year. All females are vaccinated once a year against Leptospirosis.

There are economies of scale apparent in cattle production in the Bolivia. Total production costs on small, medium, and large ranches are estimated to be around: $1.13/kg, $0.72/kg, and $0.61/kg, respectively (Table IV-3). Fixed costs of production, which include administrative costs and depreciation costs, range from: 60 percent for small, 56 percent for medium, to 50 percent for large producers.

Table IV-3 Cattle Production Budgets for the Chiquitanía (San Ignacio - San Jose de Chiquitos)

Description	Small		Medium		Large	
Hectares	500 ha.		1,000 ha.		2,500 ha.	
Number of cows	250 cows		610 cows		1,200 cows	
Beef production	13,812.5 kg		33,702.5 kg.		66,300.0 kg.	
Cost description	$ total	$/kg.	$ total	$/kg.	$ total	$/kg.
Fixed costs	9,280	0.67	13,751	0.41	20,492	0.31
Depreciation	2,927	0.21	4,568	0.14	7,776	0.12
Administrative	6,353	0.46	9,183	0.27	12,716	0.19
Variable costs	6,292	0.46	10,660	0.32	19,951	0.30
Labor	2,161	0.16	2,165	0.06	3,829	0.06
Replacement animals	1,080	0.08	1,880	0.06	3,480	0.05
Health	575	0.04	1,331	0.04	2,570	0.04
Miscellaneous	846	0.06	1,974	0.06	3792	0.06
Sales/marketing	1,230	0.09	2,910	0.09	5,880	0.09
Technical assistance	400	0.03	400	0.01	400	0.01
Total production costs	15,572	1.13	24,412	0.72	40,444	0.61

Notes: Totals may not add due to rounding.
Source: CAO, 1996.

D. Land Clearing, Fencing and Grasses

There are several methods of land clearing, and the appropriate one will vary according to forest type and operator preference. For lower, sparse forest typical of much of the Chiquitanía the choice is often "cadeneo" or chain clearing, which consists of dragging a large chain between two bulldozers. At $90 to $120 per hectare this is a very cost effective method for low forests. One month after the Acadeneo@ the land is burnt, then seeded. Seeding is done by hand, on horseback, on tractor, or by agricultural airplane. Four months later, the grass will be dropping seed, and cattle can/must be allowed on. The land is burnt again in the second and third years, and the field should be effectively grassed. The schedule is roughly as follows: clear in August, burn and seed in September/October, and put cattle on in February. However, because of the remaining stumps and half-burnt logs, mechanical control of brush and weeds is not feasible for many years.

With taller forests, Acadeneo@ is less feasible. Instead, bulldozers push trees and brush into windrows. "Dead windrows" consist of piles of brush to be burnt and the area eventually grassed. Live windrows are left as standing forest for windbreaks and refuge for cattle during periods of cold, windy weather. By pushing 30 meters in each direction, an opening of 60 meters is created. Three such swathes, plus two intervening "dead windrows" of 15 meters each gives a total width of 210 meters. Then a live windrow of 60 meters should be left. This method, typical of that used with mechanized farming operations, is much more expensive than "cadeneo," but has the advantage of allowing mechanical control of weeds. Clearing costs can range from $300 to upwards of $550 per hectare, depending on the density of the forest, the remoteness of the region, and the size of the area to be cleared.

Other methods are possible, where trees are cut by hand, possibly using chainsaws. Hand clearing implies leaving stumps, which for tropical hardwoods will remain in the ground for over 20 years, complicating weed and brush control.

In areas closer to markets, timber might be sold before burning, but as stated in the previous chapters, local markets for common species used in construction are limited.
Of the wood products used on-farm, by far the most important is the use of trees as fence posts. The logs are quartered, and depending on the size of the trunk will give anywhere from 4 to 10 posts per tree. Large posts (machones) are placed every 100 meters at 75 cm deep, and smaller ones every 5 meters at 60 cm deep. In this manner, 200 posts are needed per kilometer. The most popular species are very hard woods such as Cuchi (*Astronium urundeuva*).

With the exception of the Beni plains, improved grasses are a viable option for cattle ranching in much of the lowlands. In Santa Cruz, a total of 61,090 hectares have been planted to date (CAO 1996). Although there have been substantial reports of declining pasture productivity in pasture created from tropical forests in Brazil (Buschbacher et al. 1988), in most of the areas of Bolivia, it is accepted that grasslands can remain productive over long periods of time and, in fact, suffer more from problems of weed infestation rather than declines in soil productivity (Killeen 1991).

The most popular grasses are of the genus ABrachiaria.@ *Brachiaria decumbens* performs best on well-drained soils and is considered by some to be the best all-around grass for much of the Bolivian lowlands--because of its ability to resist trampling and provide forage during the dry season. ABracharion@ *(Brachiaria brisantha)* is also used, but does substantially worse where drainage is limited. *Brachiaria humidicola* will tolerate both well-drained and poorly-drained soils and can survive in areas of standing water for long periods. It is also tolerant of dry conditions as are the other two Brachiarias. However, it does not have as high a nutritional value as the other two and is therefore good for breeding and growing, but not for fattening. Tanner grass *(Brachiaria radicans*) performs well in areas subject to flooding, and will tolerate dry conditions, but must be planted by stolon, rather than seed, which is labor intensive. Other Brachiara species which are becoming commercially available are *Brachiaria dictoniana* and *Brachiaria ruziziensis.*

Table IV-4 Characteristics of Selected Grasses

Grass	Min Precip.	Cold tolerance	Drought resistance	Flood tolerance	Soil quality	Percent protein	Prod. (MT/ha.)
B. brisantha	1,000	low	medium	low	low/med	6.29	50
B. decumbens	800	low	medium	low/med	med	4.1	60
B. humidicola	1,000	medium	med/high	med/high	low/med	2.3	45
B. ruziziense	1,000	low	low	low	med/high	6.29	50
Colonión	1,000	low	low/med	low	high	12.2	50
Tanzania	800	low	low/med	low	high	12	60
Tobiatá	800	low	low/med	low	high	10	60

Source: Sementes California

Another popular grass is Yaraguá *(Hyparrhenia rufa)* which especially predominant in the Chiquitanía. It is palatable when young, and very vigorous on well drained land, such that it will tolerate poor land if drainage is adequate. It does not tolerate dry conditions and if not properly managed can become lignified. Finally, Guinea grass *(Panicum maximum)* and assorted improvements (Tanzania, Tobiatá, Centenario) are thought to be among the best fattening grass in South America. They need well-drained soil but do not do well in dry conditions. These grasses can often be seen in cut-and-carry operations for breeding stock.

E. Transportation of Beef to Market

Most of the beef in Bolivia is transported live, either by herding, truck, rail or river. Shrinkage, or weight loss during transport, is an important factor with this kind of transport. When there is a central shipping point, an additional cost is associated with bringing cattle from ranches, either by herding or trucking. This is the case of rail shipment from San José or Roboré in the Chiquitanía, for example. In other sites, cattle are trucked directly from the ranch to market. Only recently, ranchers in the Beni have begun slaughtering locally and shipping beef sides to La Paz. Cattle are herded or trucked during the dry season to the abattoir in the San Borja-Santa Rosa area in the Beni, slaughtered there, and the beef shipped by refrigerated truck to La Paz. The reader should refer to the Statistical Annex for transport cost estimations by region, which vary from about $40 to over $125 per head, or an equivalent of $0.21 to over $0.67 per kilogram of beef on the hook.

Shrinkage is highest in the northern regions which involve shipping live cattle by truck for distances of 700 kilometers over three to four days. Next are the Chiquitanía and Chaco which involve two days of shipping by rail or truck.

SECTION V
ANALYTICAL MODEL OF CATTLE AND TIMBER PRODUCTION

Models that simulate reality are used to uncover the relationships among variables of interest and extract conclusions useful to decision makers. Complexities are simplified by model designers to demonstrate the causal impact of independent variables--such as stumpage values or transportation costs--on dependent variables--such as the rate of land clearing. This chapter details assumptions concurrent with a description of how the model functions. In addition, descriptions of the individual study regions in which the trade-offs between cattle and timber production take place are provided. The reader may also refer to the statistical annex specifying values used in the model.

A. Methodology

The methodology used in the economic analysis is linear programming. Linear programming is a general optimization technique which can be used to examine the optimal allocation of scarce resources (Buongiorno and Gilless 1987). Linear programming has been used successfully for many years in operations research for both agricultural and forestry production. The model presented here is a dynamic, multi-year, program that examines the addition of forestry into a cattle production scenario.

B. Model Description and Format

Contrasted to many other countries, it is expected that up to half of the productive forest in Bolivia are found in private properties. The results of the model will help to examine how private land owners would use this land resource given two production options: beef cattle and managed forest for sale of timber. The analysis is approached in two steps:

- first, the base model compares results among six study regions of the lowlands which will provide insights about the regional differences that might affect rates of forest conversion to pasture, and

- second, parametric changes are tested which could affect the outcome in any given region, as a means of analyzing how different policy options may affect rates of land conversion to pasture.

The model examines the behavior of a single landowner over a 20-year production cycle in 10 periods of two years each. The objective function of the model is to maximize disposable income plus the total value of capital assets at the end of the 20-year period. Capital assets include ending value of forest land and pasture land, and the value of the cattle herd. Disposable income is that which is removed from the system at any time during model execution. The sum of the discounted disposable income stream is then added to the discounted value of capital assets to obtain the total value of the operation.

C. Data Applied in the Model

The data applied in the model was gathered from various sources, including documents and interviews, plus forest management plans recently submitted to the Superintendent under the new Forestry Law. The eight forest concessions, one indigenous territory and one private holding used for reference in this study are shown on the map on the following page, and are described in detail in Statistical Annex Table. These forest units were chosen because of their representation of the six study regions and the availability of management plans with quality data within the time frame for the study.

The study team visited most regions during the course of the research. Still, much of the data is general, and although six regions are included in the study, there was no attempt made to fine tune data for each region. Instead, most factors used in the model--such as pasture land prices, land taxes, and indices of cattle productivity--are identical among regions. This is in recognition of the weaknesses in some of the data on the one hand, and also a desire to vary only those factors of interest for the study on the other--transportation costs and annual allowable cut of timber, for instance.

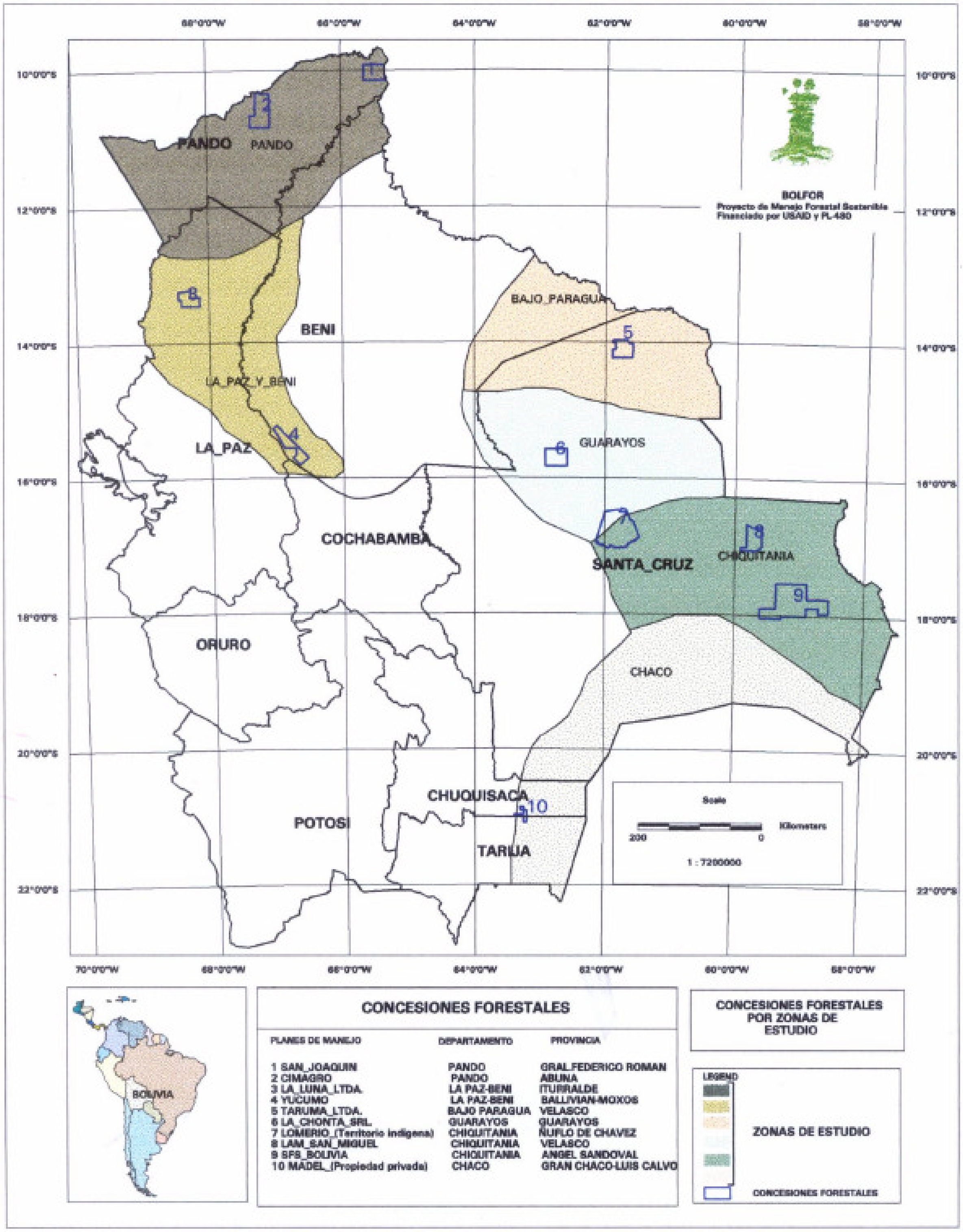
D. Land Resource

Land is treated as a homogeneous resource and is, at the beginning of the model, fully forested. There is no natural pasture available, nor does the forest provide any support for cattle. Therefore, in order to produce cattle, the landowner must first clear the land, fence and establish pasture. The amount of land available for an individual landowner is arbitrarily set at 2,000 hectares. Land is provided without cost at the beginning of the model, but it is assumed that it will establish value over the 20-year period. Therefore, ending land values are an important factor in the model. For land remaining in forestry, the highest use market value at the end of the 20-year period is applied, which assumes the possibility of conversion to pasture. This value is equal to that of pasture land less cost of conversion from forest to pasture. Another alternative tested is when forest land will remain in sustainable forest management for the foreseeable future, in which its value will reflect its ability to produce timber. This is known as the land expectation value, which is estimated by discounting the net returns per hectare into infinity.

E. Financial Parameters

The model is designed to explore the alternative uses of the land resource, rather than alternative uses of capital. The latter might imply including both investment and lending options at market rates of return on capital prevalent in Bolivia. Current interest rates in the Bolivian banking system are high by international standards, precisely because of scarcity of capital--typically 8-9 percent for medium-term deposits and 15-16 percent for borrowers. The model recognizes that both beef cattle production and forest management are long-term options which may likely not provide the same cash returns as other alternatives. Therefore, instead of using market rates of interest, the time-value of capital was accounted for in accord with the two production alternatives considered in the study by applying a discount rate of 5 percent.

MAP


PANDO
BENI
LA_PAZ_Y_BENI
LA_PAZ
BAJO_PARAGUA
GUARAYOS
COCHABAMBA
SANTA_CRUZ
CHIQUITANIA
ORURO
CHACO
CHUQUISACA
POTOSI
TARIJA
BOLFOR
Proyecto de Manejo Forestal Sostenible
Financiado por USAID y PL-480
Scale
Kilometers
200
0
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BOLIVIA
CONCESIONES FORESTALES
PLANES DE MANEJO
DEPARTAMENTO
PROVINCIA
1 SAN_JOAQUIN PANDO GRAL.FEDERICO ROMAN
2 CIMAGRO PANDO ABUNA
3 LA_LUNA_LTDA. LA PAZ-BENI ITURRALDE
4 YUCUMO LA PAZ-BENI BALLIVIAN-MOXOS
5 TARUMA_LTDA. BAJO PARAGUA VELASCO
6 LA_CHONTA_SRL. GUARAYOS GUARAYOS
7 LOMERIO_(Territorio indigena) CHIQUITANIA ÑUFLO DE CHAVEZ
8 LAM_SAN_MIGUEL CHIQUITANIA VELASCO
9 SFS_BOLIVIA CHIQUITANIA ANGEL SANDOVAL
10 MADEL_(Propiedad privada) CHACO GRAN CHACO-LUIS CALVO
CONCESIONES FORESTALES
POR ZONAS DE
ESTUDIO
LEGEND
ZONAS DE ESTUDIO
CONCESIONES FORESTALES

There is no restriction on capital available, therefore there is no option to borrow capital, and also there is no constraint on removal of capital from the operation in the form of disposable income.

Initial investment is determined by the model to the extent available capital is utilized. It should be noted that forest management requires no initial capital in the model, and as will be seen in the results, the cattle sector attracts relatively little investment. Therefore, the initial $300,000 of capital provided by in the base model is more than sufficient in all the iterations tested.

F. Parameters Driving Beef Cattle Production

To begin a cattle herd, the landowner must first clear some of the 2,000 hectares of land available. No initial cost of acquiring land is considered in the model.

The base model assumes that all marketable timber can be sold from the cleared land, but at current low stumpage prices. In actuality, most of the timber available on land cleared today is burnt, not sold, because of the limited local market. However, it is felt that as the lumber industry develops and greater amounts of forests fall under management, this situation might change and the available timber will be taken off before the land is cleared. The effect, however, is that the cost of converting land from forest to pasture is significantly reduced. That is, consistent with the concept of Bolivian law, sale of all timber available is not an option unless the land is being cleared for conversion to another use. Therefore, the model does not allow the cash obtained from timber sale when clearing land to be added to disposable income, but instead the revenue is applied exclusively to reduce cost of conversion.

The costs of clearing varies according to regions due to differing stand densities--the more dense the more expensive to clear. In addition there is currently a $15 tax on land clearing that the land-owner will incur plus a 30 percent value tax (see chapter 2 for details). After clearing, the land must be grassed and fenced. The final calculation for net cost of pasture establishment is the clearing cost, the clearing tax, and the cost of pasture establishment minus the income generated from selling timber.

Annual property taxes on each hectare of pasture are estimated according to the scale shown in Chapter 2, at an average $0.38 per hectare. The pasture carrying capacity varies among regions, roughly according to rainfall, but the range is only from one to two hectares per animal. The small range is due to the fact that the pasture consists of improved grasses which are selected for the conditions specific to each region.

After clearing land the owner has the option to begin a cattle herd. A cattle herd can be created through a breeding program, beginning with the purchase of cows and bulls. Bulls are needed to service the cows at rate of 20 cows per bull. The cost of purchasing an animal is assumed to be approximately the same for each region--$250 per cow and $280 per bull, less costs of transportation to the region, as purchase would be made locally and livestock is lower in value as one gets farther from market centers.

A 60 percent calving rate is applied--a rate not actually attained by most cattle ranchers today. Again, the model considers a future more desirable situation than that existing today. Heifers are raised until two years old at which point they can either be sold or included in the cow herd. Steers can be sold at four years old. Heifers are sold for $200 at the farm gate so transportation is incurred by the buyer. On the other hand, steers are sold to the abattoir in market cities. The cost of transportation to the abattoir is incurred by the landowner. Fixed and variable costs of production are included. There is a fixed cost of $1,000 and an annual maintenance cost based on the number of cows in the herd. Finally, there is a two percent annual death loss in the cattle herd.

G. Forest Management and Revenues

All land that is not converted to pasture is considered to be in managed forest, and an average annual management cost of $5.60 is applied to each hectare. A lower cost of $2.73 was applied in the Chaco, assuming that forest management in the region would in reality be carried out on larger properties, and fixed costs of management are spread over larger areas. The 2,000 ha total area available is maintained, however, for all regions to make comparisons of results among regions easier. Forest land taxes are minimal, but are also included in costs.

Most forest management activities relate to medium-term and annual planning, road building, marketing and supervision of harvest. As depicted in Chapter 3, many of these costs are relatively fixed with relation to the size of the forest unit, and therefore costs are lower per hectare for larger units, as costs are spread over more hectares of forest. In reality, it would be expected that owners of medium- and small-scale woodlots might not prepare annual plans, but would instead sell a portion of their timber every so many years. For instance, a person with 1,000 hectares might not offer 50 hectares per year, but instead 250 hectares every fifth year to lumber companies.

Gross revenues from managed forests are not based on current stumpage prices, which are a reflection of poorly developed log markets, lack of control over the resource, and oversupply to local lumber markets. Instead stumpage prices are based on the concept of timber sales to established lumber industries that have access to export markets. The role of the landowner is to manage the forest and place approved woodlots up for sale on a scheduled rotation. The end result applied in the model is an average net income per hectare representing the returns under a sustainable management regime. Stumpage volume or annual allowable cut was taken from current concession management plans in each study region.

H. Objective Function

The objective of the landowner is to maximize a combination of capital assets and disposable income. Capital assets are described by land, both in forest and pasture, and the cattle herd. Disposable income is the cash that the land-owner removes from the system during the twenty year cycle. Both capital assets and disposable income are discounted back to present values.

I. Site Descriptions

The following site descriptions are of the six regions examined in the model. The regions span much of the area where there is potential for conflict between cattle and forests, and stretch from the very southeast of Bolivia up to the northern section of the lowlands in the Pando. The regions are described as: Chaco, Chiquitanía, Guarayos, Bajo Paraguá, La Paz-Beni, and Pando, and are based, in part, on the following studies: Killeen et al. 1993; MDSMA 1995; ITTO 1997.

Site 1: Chaco

Located in the Departments of Santa Cruz, Chuquisaca, and Tarija, in southeastern Bolivia, the Gran Chaco is part of the larger geographic formation known as the Chaco Boreal. This extensive area also encompasses large areas of Paraguay and Argentina. Average annual precipitation ranges from 300-1000 mm with a transpiration index at around 1,200 mm. The Chaco suffers from a high degree of wind erosion. Soils are mainly sandy and saline with a high cation exchange, and a mosaic of textures. The altitude ranges from 150 to 500 m.a.s.l.

The principal forestry products are railroad sleepers, charcoal, and browsing for cattle from scrub formations. There is limited potential for both forestry and cattle production in the Chaco, yet these remain the principal economic activities for the region.

Site 2: Chiquitanía

Situated north of the Chaco on the east side of the country and comprising approximately seven million hectares, the Chiquitanía is on the Brazilian Shield and averages 1000 m.a.s.l. It is undulating terrain with mostly subtropical dry forest which receives annual rainfall from 900-1,200 mm. This region has a seven months dry season allowing lengthy forest harvest operations. The soils have the following characteristics: poor chemical content, well-drained, red clay soils, acidic, high exchangeable aluminum, and low fertility (oxisols, ultisols). There has been a permanent settlement in this area for a long period, primarily by indigenous populations and there is a high level of cattle production activity. The forest is comprised mainly of very dense hardwoods with no mahogany.

Site 3: Guarayos

The Guarayos formation, located immediately northwest of Chiquitanía, comprises approximately 8.5 million hectares. Also part of the Brazilian Shield it shares many characteristics with the Chiquitanía. The primary difference is a higher annual precipitation of approximately 1,800 mm. It is classified as having sub-tropical moist forest. The soils are primarily well drained, red clay soils, high exchangeable aluminum, and low fertility (oxisols, ultisols). Timber harvest operations in this area can take place four-five months of the year but are impeded by heavy rains during the wet season. The Guarayos site contains forest with mixed inventories of hardwoods and softwoods. Mahogany occurs in low volumes. There is a strong presence of cattle production in this region.

Site 4: Bajo Paraguá

The Bajo Paraguá site lies to the north of Guarayos and represents an area of approximately 5.5 million hectares. It is a sub-tropical moist forest which receives an annual rainfall of 1,600 mm and is an average of 800 m.a.s.l. There is great variability, however, for the most part the soils are well-drained, red clay, with low fertility (oxisols, ultisols). Located in the northeast part of the country with poor infrastructure, this remote region has very low population pressure. Transportation costs for both agricultural and forest products is very high with log trucks often taking three to four days to reach Santa Cruz. The dry season is prolonged and severe, allowing forest harvest for five-six months, but creating problems for agricultural production. There is currently little cattle production activity in the area. There is a high percentage of dense hardwoods, and a low-medium frequency of mahogany.

Site 5: La Paz-Beni

The area described here stretches north from the Andean foothills, and encircles the Beni plains. It includes the Chore region covering 1,000,000 hectares of subtropical moist forest with an average annual rainfall of 2,000-2,800 mm. This area is an ancient alluvial plain with sandy loam soils of variable texture and adequate fertility. Poor drainage and high rainfall combine to create frequent flooding, saturated soils, and very difficult transport conditions for six months of the year, however it has great timber production potential (ITTO 1996). There are strong colonization pressures in some area in this site, but are more controlled than those of the Guarayos site. The log harvest schedule is limited to three months per year due to the excessive flooding. There is moderate cattle production currently underway.

Site 6: Pando

Although part of the Amazonian forest, the Department of Pando region shares many characteristics with the Chiquitanía and Guarayos sites. Precipitation ranges from 1,800-2,000 mm and there are only 3 dry months. The predominant soils are again oxisols and ultisols as described above but vary considerably. Forest production is considered to be higher than in the Guarayos and Chiquitanía sites. Indeed, 19 new concessions have been granted in this Department since the passing of the new forest legislation. Cattle production options are low with considerable market and transportation constraints.

Table V-1 on the following page provides the values used in the base model, as will be explained in the following chapter.

Table V-1 Parameters for Six Study Sites--Base Model

Description	Units	Gran Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz Beni	Pando
Gross earnings	usd/ha/yr	2.27	6.34	13.60	9.96	8.65	11.59
Cost of	usd/ha/yr	2.73	5.60	5.60	5.60	5.60	5.60
Forest patent or	usd/ha/yr	0.03	0.03	0.03	0.03	0.05	0.05
Net earnings	usd/ha/yr	0	0.71	7.79	4.33	3.01	5.94
Ending value of	usd/ha	8	296	292	111	188	140
Pasture							
Land clearing	usd/ha	234	335	482	592	541	533
Sales of timber,	usd/ha	7	46	189	118	144	87
Area tax on	usd/ha	15	15	15	15	15	15
Net cost of land	usd/ha	242	304	308	489	412	460
Property taxes	usd/ha/yr	0.18	0.38	0.38	0.38	0.38	0.38
Pasture	ha/head	2	1.5	1	1	1	1
Ending value of	usd/ha	250	600	600	600	600	600
Cattle							
Purchase price	usd/head	195	211	215	179	197	145
Purchase price	usd/head	225	241	245	209	227	175
Mortality rate	percent	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Calving rate	percent	60%	60.00%	60.00%	60.00%	60.00%	60.00%
Annual	usd/head/	12.62	12.62	12.62	12.62	12.62	12.62
Sales price--	usd/head	200	200	200	200	200	200
Sales price--4	usd/head	280	280	280	280	280	280
Cattle transport	usd/head	54.55	39.40	35.18	70.68	52.66	105.16
General							
Discount Rate	percent	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Size of Property	hectares	2,000	2,000	2,000	2,000	2,000	2,000

SECTION VI
ANALYSIS OF RESULTS

A. Introduction

The analysis was carried out in two steps. First the basic set of assumptions were used to determine values of the parameters that drive the model, focusing on the comparison of results among the six study regions. Physical results and financial results are reported in some detail for this base analysis. Subsequently, sensitivity tests are performed by varying different parameters, one at a time, and comparing results in each region with the base mentioned above. Results from sensitivity tests focus mainly on rate of deforestation. Sensitivity analyses are performed on the variables of interest for policy purposes, especially those that have more influence over the results.

The first sensitivity test is done on the costs of land conversion, where two alternative scenarios are compared: 1) the base where timber is sold at the time of clearing, offsetting part of the cost of converting land to pasture (base), and 2) the alternative where no timber is sold, but is instead burnt off at the time of clearing.

Second, sensitivity analysis looks at the returns to forestry, which are a function of many factors, such as:

- Utilization of multiple species, timber markets and prices, efficiency in processing, transportation via export corridors, and others affecting income, plus
- Costs of forest management, local transportation costs, land taxes, and others affecting costs.

To subsume all the above into a single analysis, different levels of gross returns per hectare are used at levels centered around the base of 50 percent of estimated potential gross income from managing forests.

Third, the analysis turns to speculative future values of pasture land and forest land at the end of the 20-year period. Pasture land values are arbitrarily assumed at a level higher than those of forest land. The base has forest land value equal to pasture land value less the cost of conversion--on the premise that the landowner may still convert the land to another use if desired in the future. Other cases are where forest land values are lower than this potential market level.

Fourth, the effect of different levels of land taxes are considered, specifically with three higher property tax levels on pasture land.

Finally, it should be borne in mind that the model was run with no constraint on available capital, and with a low discount rate of 5 percent. The purpose is to allow the model to determine the relative attractiveness of two land use alternatives, on the understanding that neither forest management nor beef cattle might be highly competitive activities in comparison with other alternatives for capital. As a result of having unlimited capital and a low discount rate, the magnitude of deforestation resulting from some of the iterations of the model may be overstated with respect to time. The cattle sector may attract less capital within the next 20 years than the amounts of investments suggested in the model. Therefore, the comparison of results have validity regarding the relative impacts of the various factors considered among the several study regions, but is not necessarily valid in regard to specific annual rates of deforestation.

B. Initial Comparison of Results Among Six Study Regions--Base Analysis

The parameters driving the base model were shown in Table V-1 in the previous chapter, and physical results regarding the amounts of land cleared and build up of cattle herds by region are shown in Table VI-1 below. According to the results, very little land clearing occurs in the Chaco, while no land is cleared in either Bajo Paraguá or Pando. The Guarayos region, on the other hand, becomes largely deforested within the 20-year span, and the La Paz-Beni and Chiquitanía regions also have high rates of conversion to livestock. Cattle herds expand greatly in Guarayos and La Paz-Beni, and less rapidly in the Chiquitanía--this because of the lower stocking rate assumed for the latter region.

Table VI-1 Physical Results at the End of the 20-Year Period--Base

Land in Forest and Pasture, and Cattle Herd Size at the End of the 20-Year Period:	Region of Study					
	Chaco	**Chiquitanía**	**Guarayos**	**Bajo Paraguá**	**La Paz-Beni**	**Pando**
Forest (has)	,947	887	119	2,000	763	2,000
Pasture (has)	3	1,113	1,881	0	1,237	0
Total Cattle Herd (head)	6	738	1,891	0	1,232	0

A key factor that defines incentives to convert land to cattle production is that of access to markets, that is, costs of transporting cattle to market. As will be seen below, whereas potential forest income in Guarayos is the highest of all regions, there is still a strong tendency toward converting land to livestock ranching. The two more distant regions, on the other hand, show little proclivity toward deforestation in this base model.

Table VI-2 provides a view of financial results, with initial investment, followed by average annual net capital accumulation derived from cash, cattle and land in both pasture and forests. Initial investment is determined by the model, drawing on available capital as required to clear land and purchase breeding stock. In no case did the model utilize the entire $300,000 of capital available. The model construct does not consider that forestry management requires initial capital, but rather treats initial costs of building roads and preparing management plans as an annual cost, spread over five years.

In the base situation, returns to the combined cattle-forestry operation in the Chaco are negative, while highest combined returns are found in Guarayos. Chiquitanía and La Paz-Beni have substantial gross returns, while those in Bajo Paraguá and Pando are less, but in those cases, with no initial investment.

Rates of return are not calculated because in regions where forestry is the only activity, no initial investment is required, given that the costs of acquiring land and establishing a base for physical supervision (such as access road, house and water system) are not included in the model.

Table VI-2 Financial Results at the End of the 20-Year Period--Base

Initial Investment and Average Annual Accumulation of Capital in Cash, Land and Livestock :	Region of Study					
	Chaco	**Chiquitanía**	**Guarayos**	**Bajo Paraguá**	**La Paz-Beni**	**Pando**
	(USD 000)					
Initial Investment	12.9	170.5	146.0	0	220.7	0
NPV of Cash Accumulation per Year	(1.0)	0.6	1.9	2.5	1.4	4.6
NPV of Pasture Land Accumulation per Year	0.3	12.6	21.3	0	14.0	0
NPV of Forest Land Accumulation per Year	0.3	4.9	0.7	4.2	2.7	5.3
NPV Cattle Accumulation per Year	0.1	2.7	7.2	0	4.3	0
NPV of Total Capital Accumulation per Year	(0.4)	20.8	31.0	6.7	22.3	9.9

Notes: NPV refers to net present value using a discount rate of 5% per year.
Totals may not add due to rounding.

It is interesting to note that investment in Guarayos is less than regions such as the Chiquitanía and La Paz-Beni, while gross returns are higher. This is a result of a combination of factors: lower transport cost from this region to market centers, relatively low net cost of land clearing compared with the Amazon regions, while still maintaining the favorable stocking rate of one animal unit per hectare compared with the drier Chiquitanía and Chaco.

The strong influence of ending land values for pasture land can be seen, as a large proportion of accumulated value is attributed to this capital asset--nearly 69 percent in Guarayos, 63 percent in La Paz-Beni, and 61 percent in the Chiquitanía. Forest land values (market value based on the value of pasture land less cost of converting forest to pasture) are also important, representing more than cash accumulations in five regions--all but Guarayos.

C. Land Conversion with Higher Costs of Clearing

The base model above considers that timber from land clearing sites will find a market, albeit at the current low stumpage values reported in recent surveys. In reality, even these sales of relative large amounts of timber are not likely to occur in most regions, especially remote areas, under current conditions. The model tested the alternative where timber is burned, rather than marketed, resulting in higher costs of conversion from forest to cattle. The results in table VI-3 are dramatic: virtually none of the productive forests are converted to pasture.

Table VI-3 Amount of Land Converted to Pasture Under Two Scenarios

Two Scenarios Regarding Sale of Timber at the Time Land is Cleared to Plant Pasture:	Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz-Beni	Pando
	(Total hectares cleared out of 2,000 available)					
Timber Sold When Land is Cleared (Base)	53	1,113	1,881	0	1,237	0
No Timber Sold When Land is Cleared	42	0	0	0	0	0

The small amount of clearing in the Chaco is attribute to the fact that forestry production there does not yield a positive net return, as contrasted to the other regions where net returns to forest management are positive. This result suggests that under current market conditions, with limited options for marketing timber from land clearing sites and the high cost of conversion, landowners with productive forests in Bolivia may indeed find it in their interest to manage productive forests in virtually all regions, even Guarayos where the tendency toward conversion seems to be greatest

D. Returns to Forest Management

Gross returns to forest management are determined by the volumes of timber reported in the annual allowable cut contained in the various management plans used in the study, plus the prices of timber as described earlier. The volumes annual allowable cut suggest the utilization of a wider range of species than is currently marketed, and prices are based on export prices reported for international markets, less costs of extraction, milling and transport. Therefore, the gross revenues estimated for each region represent potential values that might be possible if conditions were ideal. Accordingly, the base used in the model is predicated on an arbitrary level of half the potential gross revenue. The sensitivity analysis considers two levels below and two levels above the base level of 50 percent. Table VI-4 shows the net returns that result from these different levels of gross revenues.

The multiple factors that might give rise to achieving these different levels of gross and net revenues are not explicitly stated. Rather the different levels used in sensitivity analysis can be related to the different levels of income. For instance, an increase in net revenue in La Paz-Beni from $3.01 to $4.74 per hectare per year could be because increases in gross revenues or because of cost reductions. Gross revenues to forest managers increase with greater utilization of multiple species, better access to export and local markets, improved markets for stumpage and logs, prices and value added to wood products, improved transportation, efficiency in processing, and others.

Table VI-4 Relevant Range of Possible Net Forest Revenue by Region

Net Annual Earnings from Managed Forest when Gross Revenue is:	Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz-Beni	Pando
	(USD per hectare per year)					
70% of Potential	0.42	3.24	13.41	8.32	6.47	10.57
60% of Potential	0	1.98	10.69	6.32	4.74	8.26
50% of Potential (Base)	0	.71	7.97	4.33	3.01	5.94
40% of Potential	0	0	5.25	2.34	1.28	3.62
30% of Potential	0	0	2.53	0.35	0	1.31

Costs of forest management were estimated at $5.60 per hectare annually, except for the Chaco where a value of $2.73 per hectare per year was applied. Most forest management activities relate to medium-term and annual planning, road building, marketing and supervision of harvest. Many of these costs are relatively fixed with relation to the size of the forest unit, and therefore costs are lower per hectare for larger units, as costs are spread over more hectares of forest. Management of forest units of 5,000 hectares might reduce costs per hectare to about half.

Other cost variables include the operator's efficiency in preparing annual operating plans, marketing and supervising, and building and maintaining roads. It would be expected that owners of medium- and small-scale woodlots might not prepare annual plans, but would instead sell a portion of their timber every so many years. For instance, a person with 1,000 hectares might not offer 50 hectares per year, but instead 250 hectares every fifth year to lumber companies. Also the model assumes that the requirement to establish research plots will be relaxed for individual landowners managing less than, say, 5,000 hectares of forest.

Again, these variables are not explicitly dealt with, because their effects translate into changes in net revenues, and the model was already run for a series of scenarios shown in the table above. Instead, the various scenarios regarding net revenue per hectare described in Table VI-4 are sufficient to consider the impacts of various income and cost factors.

Table VI-5 provides the results corresponding to the different levels of gross and net income by region in terms of amount of land deforested. The base situation where net revenues vary from zero to nearly $8.00 per hectare of forest result in rates of deforestation over 50% in the Chiquitanía and La Paz-Beni, and approaching 100% in Guarayos, while there is little conversion in the remaining three regions. Interestingly, when forest revenues increase above the base, deforestation drops off abruptly. If landowners were able to obtain a very high--and perhaps improbable--level of 65% of estimated potential value from the forest, net revenues would soar to a range of $0.42 to $13.41 per hectare, and incentives to convert land to pasture would become insignificant.

Table VI-5 Amount of Land Converted to Pasture at the end of 20 Years with Different Levels of Gross Forest Revenue

Total Amount of Land Converted When Gross Forest Revenue is:	Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz-Beni	Pando
	(Total hectares cleared out of 2,000 available)					
70% of Potential (and above)	1	0	0	0	0	0
65% of Potential	19	256	0	0	0	0
60% of Potential	53	1,196	946	0	0	0
55% of Potential	53	1,155	1,677	0	418	0
50% of Potential (Base)	53	1,113	1,881	0	1,237	0
45% of Potential	53	1,725	2,000	0	1,197	0
40% of Potential	53	1,967	2,000	0	1,155	0
35% of Potential	53	1,967	2,000	0	1,375	0
30% of Potential (and below)	53	1,967	2,000	2	1,544	0

On the other hand, as net revenues fall to lower levels, dropping to zero in the Chiquitanía and La Paz-Beni, rates of deforestation increase significantly. However, even at the lowest level of gross income tested in the model (30% of potential), and annual net revenues of $0.35 and $1.31 in Bajo Paraguá and Pando, respectively, conversion to livestock in these regions is still not worthwhile.

Although the results should be treated with some caution, the data used in the model suggest that the tendency toward conversion of land from forest to cattle might be highest in Guarayos, followed by Chiquitanía and La Paz-Beni.

On larger forest units, where costs of managing natural forests might be roughly half the estimated $5.60 per hectare used in the base analysis, the resulting effects on incentive structures can be surmised. This situation might apply to larger properties, perhaps around 5,000 hectares, rather than the 2,000 hectares used in the base model. The levels of net revenues would become:

Chaco	$ 0.87 per hectare
Chiquitanía	3.51
Guarayos	10.77
Bajo Paraguá	7.13
La Paz-Beni	5.81
Pando	8.74

Comparing with the net income levels shown in Table VI-4, the implications would be similar to raising gross revenues to more than 60 percent of potential. Extrapolating from the results in Table VI-5, one can see that incentives for conversion would be reduced to zero in the nearly all regions, while deforestation in Guarayos might decrease from 95 to less than 50 percent. Therefore, one can conclude that the tendency to deforest land will indeed be greater in smaller parcels where costs of managing the forest are higher per hectare.

E. Effects of Speculative Land Values

The ending land values of pasture land applied in the base model are chosen arbitrarily at $600/hectare for all regions except Chaco, where $250 was used. These values more than cover the cost of converting land from forest to pasture, and result in market values of convertible forest land above those for forest use only. Values of land restricted to forest use exclusively are equal to the discounted stream of future net revenues, which is calculated simply by dividing the annual net revenues per hectare by the discount rate.

Table VI-6 shows the land values used in the model, beginning in the first row with the arbitrary values applied to pasture land. The second row contains market values for forest land as a function the first row, that is, valued at its highest use (convertible to pasture). Together, rows one and two make up the base model. The third row shows forest land values based on a restriction to forest use only, and are equal to the net present value of the annual stream of forest net income. The forth row is set to zero, simulating a situation where forest land tenure is insecure, and therefore the future speculative value of owning forest land does not enter into the incentive scheme of forest operators.

Table VI-6 Ending Land Values of Pasture and Forest Lands

Ending Forest Land Values Used in the Model According to Varying Scenarios:	Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz-Beni	Pando
	(USD per hectare)					
Pasture Land Value (Base)	250	600	600	600	600	600
Forest Land Value--Highest Use (Base)	8	296	292	111	188	140
Forest Land Value--Forest Production Only	0	14	159	87	60	119
Forest Land Value--Insecure Land Tenure	0	0	0	0	0	0

Pasture land values are held at the same level as shown above, while the model was run with the three levels of ending forest land values. Table VI-7 provides the results in terms of land conversion.

The first result of the analysis of ending land values is highly notable: ending pasture land values can be increased to any value above $600 per hectare ($250 for the Chaco), and the results of the model in terms of decisions made by the landowner and the amount of land converted to pasture remain identical. Indeed, the model was run for much higher amounts, with pasture land values placed at $1000/hectare and $2000/hectare, and the behavior of the landowner was unaltered. This implies that, with assured land tenure and no restrictive zoning, speculative land values will not affect decisions to clear land of forest. The reason is this: as speculative pasture land values increase, so increase speculative forest land values. In a perfect market for land, values for forest land would increase in the same amount as cleared pasture land, the difference between the two being the cost of conversion from forest to pasture.

Of course, if pasture land values are decreased, forest land values would also decrease in the same amount, but they encounter a floor at their value for forest use (third row in Table VI-6). This is why the base values of pasture land were set at $600 in the model--so ending values of forest land would coincide with row 2, the market value when the land can be converted to pasture. A lower value of pasture land would imply using values in row 3 instead of row 2 (not desirable as we wanted to test both alternatives).

Row 3 is includes to test a particular case--that of restrictive zoning where land cannot be converted to any use other than forestry. The model tests the extent to which this restriction would run counter to market incentives perceived by landowners, and therefore the level of resistance to such zoning that might be encountered. The results of the model can be read in terms of the behavior that landowners would attempt to attain if the zoning were put in place. Comparing rows 1 and 2 of Table VI-7 suggest that if zoning has the effect of lowering ending land values, strong incentives are created to avoid the zoning and maintain land values through deforestation. That is, the model suggests that landowners would have an incentive to deforest the land if that action would help avoid zoning restrictions and loss of speculative land value.

Row 3 in the table below shows the extent of conversion when ending forest land values are reduced to zero, reflecting a situation where the prospects for securing control over forest land is considered to be so tenuous that forest operators assume eventual loss of their access to the land.

Table VI-7 Amount of Land Converted to Pasture Under Three Scenarios of Ending Value of Forest Land

Scenario Defining ending Land Value of Forest Land:	Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz-Beni	Pando
	(Total hectares cleared out of 2,000 available)					
Highest Use Value (Base)	53	1,113	1,881	0	1,237	0
Forest Production Only	2,000	2,000	2,000	30	1,766	45
Insecure Tenure on Forest Land	2,000	2,000	2,000	316	1,766	257

When ending values of forest land are lower than those in the base model, the impacts are dramatic. Even the regions that show little tendency toward deforestation in earlier tests of the model, now become subject to having land cleared, for purely speculative reasons. Guarayos, the Chiquitanía, La Paz-Beni, and even the Chaco become 90-100 percent deforested according to the model. Curiously, results for these four regions are identical for the two cases: where ending forest land values are reduced from market levels (with conversion option) to restricted use levels, and where ending forest land values are zero. Land clearing even picks up, albeit modestly, in the two more remote regions--Bajo Paraguá and Pando--as ending forest values are reduced.

F. Differential Land Taxes

The final policy variable is land tax for pasture land, increasing to higher levels while leaving forest land taxes at their current nominal level. Taxes on land cleared and planted to pasture will in reality vary by region with land values and average size of properties. In the base model, however, a single value of $0.38 per hectare was applied in five regions ($0.18 in Chaco). Here, three higher levels were applied--$1.00, $2.00 and $3.00 per hectare. It should be remembered that the study regions considered in the model are outside the central "integrated and expansion" farming areas of Santa Cruz, but are instead in more distant areas where forestry and extensive cattle production are the dominant activities. Therefore, property values can be expected to remain low, and the higher levels tested in the model may be unlikely to attain for some time. Even the $1.00 level suggests nearly a three-fold increase. The highest level tested--$3.00 per hectare--implies total property value greater than $120,000 and a declared value of pasture land per hectare of more than $200.

Table VI-8 shows the results in terms of amount of land converted to pasture. Only the three regions that showed a tendency toward conversion in the base model are relevant to this analysis.

Table VI-8 Impact of Pasture Land Taxes on Land Use Conversion

	Chiquitanía	Guarayos	La Paz-Beni
Level of Pasture Land Tax:	(Total hectares cleared out of 2,000 available)		
$0.38/hectare (Base)	1,113	1,881	1,237
$1.00/hectare	1,088	1,849	496
$2.00/hectare	144	1,799	0
$3.00/hectare	91	1,166	0

Interestingly, the impact on conversion by increasing pasture land tax by nearly three-fold is virtually zero in two of the regions. This is seen by comparing rows 1 and 2 of the table. If indeed, this increase represents the feasible range of options, as it may well be, that differential land taxes between pasture and forest uses will have little impact on land use decisions. If, however, pasture land taxes are raised to still higher levels, then the impacts eventually begin to affect the profitability of cattle ranching and the impact on conversion can be seen in rows 3 and 4. The implication is that only when taxes on pasture land are raised to levels high enough to affect profitability of ranching, will they have an impact on incentives to maintain land in forest. However, rural property land taxes also raise money for municipalities to improve rural roads, which would tend to lead to greater deforestation at the same time.

SECTION VII
CONCLUSIONS AND POLICY IMPLICATIONS

The forest sector can generally be thought of as having two segments differentiated by target market. While lumber companies with concessions focus on exports, smaller sawmills supply the local market with construction lumber. In the past, lumber companies with concessions were very selective, favoring only high value species, but are now beginning to manage forests and utilize a wider number of species, introducing new products into export channels. First grade lumber is exported primarily to the USA, second grade to Argentina, while third grade lumber is used in the local carpentry industry. The local market for construction timber is small, therefore most timber from land clearing sites, especially of less valuable species for construction timber, is burned. This practice is especially common in more distant regions. Because of the oversupply, current stumpage prices are very low compared to potential prices based on export values.

Stumpage prices are increasing, apparently as a result of the forestry law which restricts supply from unmanaged forests. Stumpage volumes per hectare are rising in managed forests with increased use of many different species for both local and export markets.

The cattle sector is typified by extensive operations where beef cattle are bred and raised on natural grasses. Fully grown steers are shipped live directly to market centers. The two recent changes in this scenario identified in this study are: 1) fattening operations developing around Santa Cruz in which younger cattle are grown out on improved pastures, and 2) the operation of abattoirs in the Beni which allow refrigerated transport to La Paz.

The cattle sector attracts relatively little capital investment at present, implying that capital availability is not a primary constraint to cattle expansion. Relatively low productivity and high production costs, plus limited potential for market expansion are factors that imply slow growth of the sector, sparing the forests in much of the Bolivian lowlands from undue pressure up to now. Over time, as the cattle sector gradually expands, it is believed that the net returns from managed forests will also increase. Therefore, the two sectors should be able to prosper side by side.

The model shows that clearing land for cattle production as currently practiced is prohibitively expensive, without the sale of timber to compensate for the cost of clearing and establishing pasture or other cost-saving methods of land clearing. At present, it is unlikely that much of the volume of timber from distant land clearing sites will find its way into export markets. Local markets are small compared with the large volumes available from land clearing today. Therefore, the prospects for offsetting land clearing costs with sales of timber seem dim, especially in remote regions. There are less expensive methods of land clearing, but some of these methods imply subsequent limitations regarding pasture maintenance. For instance, cutting with chain saw and burning leaves stumps for many years, making weed and brush control by tractorized mowers impossible.

The three regions that consistently demonstrate greater proclivity to being deforested are: Guarayos, the Chiquitanía and La Paz-Beni. However, with relatively modest increases in forest revenues, productive forests in all regions might be maintained by landowners. The other three regions show very little tendency toward deforestation. Results of the model show that landowners in the more distant regions--Pando and Bajo Paraguá--would have a strong preference to utilize lands for forest production compared to cattle, primarily because of the significantly higher costs of transporting cattle to market. This result implies that as long as access remains poor, there would be little need for direct public intervention to maintain productive forests in the more remote regions of the country. Instead, landowners can be relied upon to maintain and manage forests, if provided proper guidance and support.

The only situation in which the model shows a tendency toward conversion of forests in either Pando or Bajo Paraguá is if forest land is worth nothing at the end of 20 years, while pasture land is worth a great deal. This result is intended to simulate a situation where land tenure is secured by clearing and grazing cattle, but land maintained in forest is subject to takeover or colonization and might therefore be lost to the forest operator.

The results of the model have the Chaco not being used for forestry, nor are significant amounts of land cleared for pasture. Although the model does not account for the possibility of the forest sustaining cattle, the reality in the Chaco is that cattle graze and browse off native plants in forested areas. This kind of extensive grazing on natural vegetation is the most likely land use for the future of the region.

Surprisingly, speculative land values do not have to create pressure to clear the forest. If pasture and forest land values both increase by the same amount (the difference between them being the cost of converting forest to pasture), then the incentives to clear the land are not changed. Land cleared, grassed and fenced for cultivated pasture can rise in value from the $600 per hectare level used in the model to $1000 per hectare, or any other higher figure, and the results in all regions remain unaltered. This is because the values of forested land that can be converted to pasture increase by the same amount, leaving the absolute difference in price between pasture and forested land unchanged. Therefore, the incentive structure to the landowner is not affected.

However, when the speculative value of pasture land rises, and that of forested land does not, the impacts are dramatic, such as when the ending land value might be lost due to doubtful tenure on forest land. A strong incentive to deforest the land is created. This is the only condition tested which produced significant amounts of deforestation in regions such as the Chaco, Bajo Paraguá and Pando. The importance of the reforms legislated in the new Land Tenure Law can easily be seen, and suggest that the concepts should be put into practice as soon as possible.

Curiously, a perverse incentive can be created by policies that would protect the forest through zoning, by depressing values of forest land. For example, if zoning restrictions in the Chiquitanía lowered forest land values from their potential ($296 per hectare when converted to pasture) to their potential exclusively for forestry ($14), then the model shows the rate of deforestation in the region virtually doubling. This result of the model reflects the incentives that landowners would have to avoid the zoning, if indeed they could do so by deforesting the land and thereby maintain its value. According to the model, even landowners in the Chaco would prefer to clear the land under such circumstances (with a reduction from only $8 to $0/hectare).

Zoning restrictions on land use could erode the speculative value, just as insecure tenure would, creating incentives to deforest the land and thereby avoid zoning restrictions. Use of zoning should be made only when the political will and capability is present. Obviously in a country with no clear land titling system, and with policies for expanding human occupation of the national territory, such political will is unlikely.

Current land taxes are relatively low for pasture and insignificant for managed forest use on private lands. Increasing land tax on pasture by nearly three fold from $.38 to $1.00 per hectare did not significantly impact on the rate of conversion of land to pasture. Of course, raising taxes to much higher amounts ($2 or 3 per hectare) does eventually affect net returns to cattle production and impacts on incentives to convert land from forestry to pasture. However, increasing land taxes on rural property would also raise additional funds for rural road improvement by municipalities, and which would tend to favor conversion to cattle production. Therefore, land taxes can have dual and contradictory impacts with regard to maintenance of forests.

Returns to forest management are the primary factor driving the model. Increases in gross revenue from 50 percent to 65 percent of estimated potential provide sufficient incentives for landowners to prefer managing productive forests rather than clearing land for cattle production, even in regions with high proclivity to conversion, such as the Chiquitanía, Guarayos, and La Paz-Beni. Even an increase in gross revenue from 50 percent to 55 percent of potential, reduces the rate of deforestation in La Paz-Beni to a fraction of the level it might otherwise be with lower forest production earnings.

Assisting landowners in their efforts to sustainably manage forests can be a powerful tool to reduce costs and improve margins. Technical assistance to facilitate desired practices in production as well as marketing forest products is probably the most effective means of supporting property owners and providing a positive environment to obtain interest and cooperation. The cost estimates of sustainable forest management developed for this study show sharp decreases per hectare with larger forest units. The costs estimated to manage forest units of 2,000 hectares of $5.60 per hectare do not appear to be insurmountable, but owner/operators with much smaller properties may find the costs prohibitive.

It should be noted that the level of comfort offered in the conclusions regarding incentives to maintain and manage productive forests do not apply in the vast areas of the Bolivian lowlands where forests are less productive. As explained above, results of the model are very sensitive to changes in both gross income from forestry and in costs of land clearing--both being lower in areas of less dense, less productive forests. Many forests prevalent in the Chiquitanía and Guarayos are of lower density and would be susceptible to conversion. The results of the model do hold, however, for the Chaco, where the model already contemplates a situation where forests productivity is low.

Finally, it should be restated that the model does not apply to situations of agricultural expansion, both small scale colonization programs as well as expansions in mechanized farming. Also the results only hold for the more remote regions--Bajo Paraguá, and Pando--as long as infrastructure remains poor and resulting transportation costs are high.

SECTION VIII
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STATISTICAL ANNEX WITH VALUES USED IN THE MODEL

Forest Densities and Productivity

The nine forest concessions and one private holding used for reference in this study are described in detail in Table 1 on the following page. These forest units were chosen because of their representation of the six study regions and the availability of management plans within the time frame for the study, which coincided with the consideration of the first forest management plans by the Superintendent under the 1996 Forestry Law. From the summarized data on the following page, forest operators have classified forest as low growing, medium or high. Low forests exist particularly in the Chaco, Chiquitanía and Guarayos, and less so in the more humid regions. Percentages of "net productive forest" are lower on average in the three regions from Chaco to Guarayos.

Total volume of all species above the minimum diameter at breast height (dbh), according to management plan inventories, is lowest in the Chaco at about 23 cubic meters (m^3) and highest in Bajo Paraguá at over 83 m^3. The minimum diameter for the MADEL inventory in the Chaco was reduced from the norm of 20 to 10 centimeters dbh. One would expect the most dense of forests to be found in the La Paz-Beni region, or perhaps Pando, rather that Bajo Paraguá. According to Tarumá managers, the site which was used to represent the Bajo Paraguá may lead to some distortions, in that it contains very dense forest, but is not known for having the most valuable species. Still it was the only data available to the researchers for this study.

Indeed, densities are very high for La Paz-Beni and Pando sites, ranging from nearly 68 m^3 in CIMAGRO to 79 m^3 in San Joaquín. The volume in La Chonta, the site representing Guarayos, is also high at 65 m^3, perhaps higher than normal for the region. Volumes in the Chiquitanía seem to be representative of that region, ranging from 33 to 52 m^3.

Volume of Annual Allowable Cut (AAC) ranges from 6.5 to nearly 17 m^3 per hectare. This means that an average of around 10 m^3 will be harvested from each hectare of forest every 20 to 35 years. The average harvest per hectare is equal to the AAC divided by the cutting cycle. AAC is highest for la Chonta in Guarayos, followed by the two sites in La Paz-Beni and Tarumá in Bajo Paraguá. Next comes the Chiquitanía, Pando and Chaco. AAC as a percent of total forest volume is higher in the more accessible regions where a wider range of available species is used, especially stretching into species of lower value. Pressure (AAC/Volume) is highest in Guarayos (35%), followed by Chiquitanía and Chaco (22-38%, because of low volumes but relatively large AAC). Lowest pressure by far, implying greatest selectivity of species, is found in the remote Pando region (10-15%). Bajo Paraguá and La Paz-Beni are similar, close to 21%.

Annex Table 1. Description of Forest Concessions Referenced in the Study

REGION	**Chaco**	**Chiquitanía**	**Chiquitanía**	**Chiquitanía**	**Guarayos**	**Bajo Paraguá**	**La Paz**	**Beni**	**Pando**	**Pando**
CONCESSION OR FOREST AREA	MADEL	CIMAL	CIMAL	CICOL SUR	LA CHONTA	TARUMÁ	LA LUNA	YUCUMO	CIMAGRO	SAN JOAQUÍN
DEPARTMENT AND PROVINCE	Chuquisaca & Tarija Lius Calvo and Gran Chaco	Santa Cruz Velasco	Santa Cruz Angel Sandoval	Santa Cruz ¼uflo de Chávez	Santa Cruz Guarayos	Santa Cruz Velasco	La Paz Iturralde	Beni Ballivian & Moxos	Pando Abuna	Pando Federico Roman
Total Area (hectares)	16,250	66,933	372,130	39,073	100,000	82,013	67,870	92,564	146,100	81,600
Productive Forest (has)	13,319	61,288	207,345	32,069	71,200	72,735	64,213	75,823	131,730	72,630
Tall Forest (has)	1,171	5,753	50,000	15,815	10,217	47,928	46,605	54,257	73,519	0
Medium Forest (has)	5,493	24,367	152,000	5,979	46,358	24,806	12,416	21,566	58,211	64,330
Low Forest (has)	6,705	31,168	5,345	10,235	14,626	0	5,192	0	0	8,300
Percent Productive (percent)	100	95	86	80	100	90	100	100	95	100
Net Productive Forest (has)	13,319	58,224	178,317	25,655	71,200	65,462	64,213	75,823	125,144	72,630
Area Approved for Annual Harvest (has)	381	2,329	5,099	732	2,373	2,205	3,010	3,744	6,257	3,200
Volume of all Species[a] (m^3)	23.4	33.05	52.1	35.74	64.95	83.36	77.26	72.37	67.87	79.11
Volume of AAC per Ha.[b] (m^3)	6.55	10.85	11.39	13.45	22.63	17.32	16.96	15.76	7.2	11.85
Pressure: AAC as a Percent of All Species (percent)	28.01%	32.83%	21.87%	37.64%	34.84%	20.78%	21.96%	21.77%	10.60%	14.98%
Cutting Cycle (years)	35	25	35	35	30	30	20	20	20	20

Notes: a) Volume in cubic meters of all trees in the forest inventory over 20 centimeters diameter at breast height (dbh), 10 centimeters in the Gran Chaco.
b) Annual Allowable Cut (AAC) approved in the 1998 Management Plan.

Cutting cycles also show consistency across regions, being greatest for the drier areas, often 35 years in Chaco and Chiquitanía, 30 years in Guarayos and Bajo Paraguá, and 20 years in La Paz-Beni and Pando.

Potential Stumpage Prices Based on Export Potential

Lumber prices reported for exports from Santa Cruz (Table 2) were obtained from the Cámara Forestal de Bolivia for 1996 and 1997. It was assumed that 70 percent of the volume could be exported. Local prices in the Santa Cruz and Cochabamba markets were applied to the remaining 30 percent.

Working back from lumber to logs, prices were first converted to USD per board foot at 424 bft/m^3, then the conversion to equivalent in logs using factors of 50% efficiency for medium density species and 40% for high density species. Extraction costs are subtracted at this point before the final conversion to timber in form of standing trees using conversion factors of 80% for medium density and 70% for high density species. Extraction and milling costs are from a BOLFOR study by Rice and Howard cited in Table 3.3 in Chapter 3. Transportation costs, on the other hand, are estimated specifically for each region (see section below). Figures in the example below apply to the Chiquitanía region.

Annex Table 2. Stumpage Prices for Managed Forest

	Lumber Prices		**Potential Stumpage Prices--Chiquitanía**	
			Medium Density	High Density
	(USD per bft of lumber)	(USD per m^3 of lumber)	(USD per m3 of timber)	(USD per m3 of timber)
High Value Species				
Morado	2.03	860.95	NA	183.80
Mahogany	1.16	491.30	131.07	NA
Roble	.86	365.06	80.58	NA
Cedro	.95	403.59	95.99	NA
Valuable Species	.81	345.16	72.61	39.38
Less Known Species	.58	243.91	32.12	11.03

Note: Weighted Averages, 70% export, 30% local prices
Source of export prices: Cámara Forestal de Bolivia
Source of local prices: BOLFOR studies by Soto and Córdova

Species were classified by high, medium and low value, and prices applied according to the average price of each class, except for the higher value species where their reported values for export and local markets were applied. (See Table 4).

Potential prices shown above are far greater than those currently paid by local sawmills. Mahogany for example could pay nearly $300 per tree rather than the $46 currently quoted. Most commercial species could pay $80 to $150, rather than $10-15 typically paid today.

Current Stumpage Prices

The study assumes that when forests are not managed, but instead are cleared for planting pasture, the landowner might obtain the stumpage prices prevailing today. Current stumpage prices were obtained from BOLFOR surveys based on prices paid by sawmills for standing timber reported in two studies, Soto 1995 and Córdova 1997. The 1997 surveys report stumpage prices for 24 species in various parts of the Chiquitanía and Guarayos of Santa Cruz, plus the integrated area of north Santa Cruz and the river port, Puerto Villarroel en the Chapare of Cochabamba. All of these areas have reasonably good access to market centers.

In the more recent survey, all but five species range in price from $7 to $12 per tree. Five species reached higher levels: Almendrillo at $17, Verdolago at $19, Cedro at $23, Roble at $29 and Mahogany was quoted at $46 usd per tree. Table 3 provides prices by value group in terms of USD per cubic meter of logs, applying a factor of 2.1 cubic meters of log from each tree.[1] The price quoted for Morado is exceptionally low, perhaps because of earlier restrictions on harvest of this species.

Annex Table 3. Stumpage Prices for Non-Managed Forest

	Stumpage Prices
	USD per m3 of Timber
High Value Species	
Morado	5.81
Magogany	22.02
Roble	13.97
Cedro	11.39
Relatively Valuable Species	5.66
Less Known Species	3.53

Note: Multiply by 2.1 to obtain price paid per standing tree.
Source: BOLFOR studies by Soto and Córdova

[1] Based on an estimate obtained in Lic. Fernando Aguilar, ex Forest Economist - BOLFOR

Annex Table 4. Common and Scientific Names of Species by Value Group

		High Value Species	
Morado	*Machaerium scleroxylon*	Roble	*Amburana cearensis*
Morado (Moradillo)	*Peltogyne sp*	Cedro	*Cedrela fissilis*
Mara	*Swietenia macrophylla*		
		Relatively Valuable Species	
Ajunao	*Pterogyne nitens*	Quebracho Colorado	*Schinopsis quebracho colorado*
Almendrillo	*Dipteryx odorata*	Sirari	*Copaifera chodatiana*
Cambará	*Vochysia sp*	Tajibo	*Tabebuia sp*
Curupaú	*Anadenanthera colubrina*	Tarara Amarilla	*Centrolobium microchaete*
Itauba	*Mezilaurus itauba*	Tarara Colorada	*Platymiscium ulei*
Jichituriqui	*Aspidosperma cylindrocarpon*	Verdolago	*Terminalia spp*
Mara macho	*Cedrelinga cataeniformis*	Verdolago	*Calycophyllum multiflorum*
Paquió	*Hymenaea courbaril*	Yesquero	*Cariniana estrellensis*
		Less Known Species	
Ajo	*Gallesia integrifolia*	Maní	*Sterculia striata*
Aliso	*Vochysia vismiifolia*	Mapajo	*Ceiba pentandra*
Azucaró, Cedrillo	*Spondias mombin*	Masaranduva	*Manilkara bidentata*
Bibosi	*Ficus sp.*	Momoqui	*Caesalpinia pluviosa*
Blanquillo	*Ampelocera ruizii*	Mururé	*Brosimum acutifolium*
Cabeza de Mono	*Zeyheria tuberculosa*	Ochoó	*Hura crepitans*
Cachichira	*Sloanea obtusifolia*	Ojoso Colorado	*Pseudolmedia laevis*
Canelón	*Aniba aff. guianensis*	Palo María	*Calophyllum brasiliense*
Copaibo	*Copaifera reticulata*	Quebracho Blanco	*Aspidosperma quebracho blanco*
Coquino	*Pouteria macrophylla*	Quinaquina	*Myroxylon balsamum*
Cuchi	*Astronium urundeuva*	Sangre de Toro-Gabún	*Iryanthera juruensis*
Cuta del Monte	*Phyllostylon rhamnoides*	Sangre de Toro-Gabún	*Virola sebifera*
Cuta	*Astronium sp.*	Serebó	*Schizolobium amazonicum*
Enchoque	*Cariniana decandra*	Soto	*Schinopsis brasilensis*
Huayruru	*Ormosia bopiensis*	Tasaá	*Acosmium cardenasii*
Isigo	*Tetragastris altissima*	Toco	*Enterolobium contortisiliquum*
Mani	*Platypodium sp.*	Trompillo	*Guarea macrophylla*

The effective exercise of control over the resource by landowners provided in the 1996 Forestry Law may explain the 50 percent average increase in stumpage prices reported from the 1995 to the 1997 survey. Because of this notable pattern, the 1997 figures were given preference. When the 1997 survey did not provide a price for a particular species, the price reported in the earlier survey was used, with an increase to the average 1997 level. Where no quote is available, the average price for less known species was applied.

Costs of Transporting Logs and Lumber

Costs of transporting logs from the forest to the sawmill and for transporting lumber on to the market/processing center are added to obtain total transport cost per region. Figures are converted to the cost corresponding to a cubic meter of stumpage.

Differing distances from the forest to sawmills were applied, depending on the general availability of sawmills in each region. In the Guarayos and La Paz-Beni areas, it would be expected that sawmills might be generally more plentiful and accessible. For transport of lumber, distance is multiplied by an average $0.66 per cubic meter-kilometer by truck, except for the Pando where river transport is involved. Here the total of river shipment plus trucking to Cochabamba came to $55.86 per cubic meter of lumber, which converts to $22.35 per cubic meter of stumpage. Rail is rarely used for internal shipment of lumber, as the cost per cubic meter kilometer is similar to that of trucking, but implies additional handling and delivery costs on both ends.

Annex Table 5. Transport Costs of Logs and Lumber by Region

Region		**Transport of Logs**		**Transport of Lumber**				**Total**
Region	Distance to Transport Logs	Conversion stumpage to logs	Cost of Trans-porting Logs	Market & Processing Centers	Distance to Transport Lumber	Conversion logs to lumber	Cost of Trans-porting Lumber	Total Transport Cost
	km		usd/m3	destination	km		usd/m3	usd/m3
Chaco	90	0.70	7.39	Sta Cruz	403	0.40	7.43	14.82
Chiquitanía	90	0.70	7.39	Sta Cruz	415	0.40	7.65	15.04
Guarayos	60	0.75	6.72	Sta Cruz	330	0.45	7.33	14.06
Bajo Paraguá	90	0.75	7.92	Sta Cruz	700	0.45	15.56	23.47
La Paz-Beni	60	0.80	7.17	La Paz	370	0.50	9.75	16.92
Pando	90	0.80	8.44	Cochabamba	1390	0.50	22.35	30.79

Notes: Costs of transporting logs and of transporting lumber are expressed in terms of dollars per cubic meter of stumpage, that is, of estimated commercial inventory of forest. To obtain costs of transport of logs or lumber per se, divide costs by the corresponding conversion factors.

Costs of Sustainably Managing Private Forests in the Tropics

Sustainable management for a private landowner who will sell standing timber involves, at the minimum, maintaining control to avoid encroachment, planning for use of the resource, supervision of extraction, and under Bolivian Law, establishment of plots for permanent measurement of tree regeneration and growth. For the purpose of the model, we make the assumption that the landowner has the means of establishing effective control over the forest production unit without incurring additional cost. This assumption is based on the idea that landowners might raise some cattle, and therefore will have a homestead with permanent staff on hand. It was also assumed that the requirement to establish plots for permanent measurement of regeneration and growth will be relaxed for forest production units of the size considered in the study.

The data used in the study are based on estimated time requirements to perform each activity and prevailing salary levels, as little data is available from actual experiences of landowners.[2] The table below summarizes the initial costs and yearly costs. Initial costs are then spread or depreciated over a five-year period. Finally, total costs are averaged over the area of the entire forest production unit. As predicted in Chapter 3, the costs of sustainable management practices is much higher per hectare for smaller units--$6.55/year for a 1,000 hectare forest unit versus $2.73/year for a 5,000 hectare unit. An estimate of $5.60 per hectare annually was applied in the model for all regions except Chaco, where a lower figure of $2.73 was used--the rational being that managed forest units in the Chaco would probably need to be more extensive than those in other regions in order to be profitable.

Annex Table 6. Costs of Sustainably Managing Private Forests of One Thousand and Five Thousand Hectares

	1000 hectares		5000 hectares	
Costs by Activity	Initial	Yearly	Initial	Yearly
Planning	(USD)		(USD)	
Preparation of Management Plan and inventory	2,510		3,963	
Preparacion of Annual Operating Plan and Census		2,250		4,450
Production				
Road Building	1,800		3,600	
Supervision		2,691		5,336
Forest Use Patent or Forest Property Tax		50		250
Other				
Marketing		700		2,100
Total Costs	4,310	5,691	7,563	12,136
Depreciation of Initial Costs		862		1,513

[2] Thanks to Lic. Fernando Aguilar, ex Forest Economist - BOLFOR

Average Annual Cost Per Hectare	6.55	2.73

The following two tables present estimated costs of preparing sustainable management plans and inventories, then annual operating plans with commercial census.

Annex Table 7. Costs of Preparing Management Plan and Inventory

	1000 has	5000 has
Costs of General Management Plan	($us)	
Fotointerpretation and mapping	500	500
Planning	70	140
Field work	355	1078
Supervision	85	185
Data processing	450	450
Preparation and Publication of Plan	360	360
Forestry Specialist	490	1,050
Preparation of document	200	200
TOTAL	2,510	3,963

Road building by private landowners is asummed to be accomplished at minimal cost, using only a crawler tractor for about six hours per kilometer. Supervision costs and marketing costs are based on time the landowner or a hired forest specialist would need to spend supervising harvest activities.

Annex Table 8. Costs of Preparing Annual Operating Plans and Census of Area to be Harvested

	1000 has	**5000 has**
	($us)	
Commercial census	550	2,750
Preparation of Annual Operating Plan	1,400	1,400
Materials	300	300
Total	2,250	4,450

Costs of Land Clearing

Costs of clearing using mechanized "acordonado" with a bulldozer and blade pushing brush and trees into windrows are estimated at about $388 per hectare for tall forest with about 65 m^3 of timber, plus about $13 per hectare for transport of equipment. Clearing also involves burning of "dead windrows" and cleaning of borders for fencing. Costs vary according to the density of the forest, with estimations lowering to $140/hectare in the Chaco and increasing to as high as $498/hectare in Bajo Paraguá.

Landowners can benefit from harvesting timber from the areas being cleared. Forest inventories in the management plans provide an estimate of the commercially available timber--an amount greater than the Annual Allowable Cut per hectare in that the entire volume of commercial timber is included, with no margin for minimum diameter or seed trees. Revenues are estimated by taking these available volumes times current stumpage prices shown above. CLARIFY Estimations of revenues from sale of timber at time of clearing (shown by region in Table 5.1 in Chapter 5) range from only $7 per hectare in the Chaco to as much as $189 per hectare in Guarayos. Therefore, net costs of clearing and establishment of fenced pastures used in the base analysis range from $242/hectare in the Chaco to $489 in Bajo Paraguá.

Clearing also requires the presentation and approval of an individual property land use plan and land clearing plan. Associated harvest of timber requires issuance of Acertificates of forest origin@ with payment of the area and volume based taxes as described in the following section.

Taxes on Land Clearing

Under the new law, land clearing is taxed on both area and volume of timber removed. The area tax or patent is currently set at 15 times the per hectare patent paid be forest concessions, or $15/hectare.[3] The volume tax is computed at 30 percent of the value of timber at the land clearing site, according to a price list established by the Forest Superintendency. The landowner pays 15 percent of the value and the buyer of the timber another 15 percent. The price list applied by the Forest Superintendency for 1998 seems to reflect international timber prices less extraction and milling costs, which are several times higher than the amounts paid by local sawmills. Therefore, timber will be extracted from land clearing sites only in cases where the landowner is able to find interested lumber industries with capacity and access to international markets. Otherwise, the timber will be burnt off, a practice common in the Bolivian lowlands.

Productivity Factors for Beef Cattle

As stated in Chapter 5, cost and productivity factors regarding cattle ranching were generally estimated for the country and do not vary in the analysis among regions. Some of the variables are somewhat more favorable than those currently attained--such as the ratio of cows per bull set at 20, the maturity of heifers which join the cow herd at 2 years of age, and the calving rate at 60 percent. Current estimates of these factors in many parts of Bolivia would suggest only about 15 or fewers cows per bull, heifers maturing at 3 years or more, and calving rates of 45 to 55 percent. The reason for using more favorable figures is to reflect productivity indices that might be attained in situations where cattle are raised on cultivated pastures, rather than on primarily natural grasses.

[3] The forest concession patent was initially set at $1 per hectare. It can be adjusted upward in future years with changes in international tropical timber prices, but can never be lower than $1/hectare.

Stocking rates are set at 1 hectare per animal unit for all regions except the two which have lower rainfall. The rate for the Chiquitanía was put at 1.5 hectares and for the Chaco at

2 hectares to support a single animal unit. The authors admit that there is relatively little information available to defend this precise numbers.

Sales prices of beef and weight/age of slaughter reflect current market conditions, described in Chapter 4. There might be a tendency for beef prices to fall in the future, however the authors did not feel confident in speculating about this possibility for incorporation into the model. Purchase prices of breeding stock are set at sales price less transport cost to the region. Breeding stock is available at low cost in many regions, sometimes by importing on the hoof from Brazil, where policies limit ranchers' ability to slaughter heifers. One-and two-year old heifers are available for as low as $80 to Bolivian ranchers at the border.

Fencing is estimated to run about $376 per kilometer, assuming the terrain has already been cleaned when the land was cleared, and that posts are available on the property. Wire in 500 meter rolls requires 8 rolls/kilometer when using 4 strands stapled to posts. With pastures of 50 hectares, the average cost of fencing per hectare comes to about $21. Establishment of pasture requires approximately another $40 for seed and $20 for seeding. Other investment costs for items such as water systems, corrales, and infrastructure for housing are not considered in the the study. An average annual fixed cost of $1,000 is included to reflect these costs, besides the annual maintenance cost per cow of $12.62.

Costs of Transporting Cattle and Beef to Market

Most of the beef in Bolivia is transported live, either by herding, truck, rail or river. Shrinkage, or weight loss during transport, is an important factor with these kinds of transport. Only recently, ranchers in the La Paz-Beni region have begun slaughtering locally and shipping beef sides to La Paz in refrigerated trucks.

Annex Table 9. Costs of Transporting Cattle and Beef from each Study Region to Market

	Gran Chaco	Chiquitanía	Guarayos	Bajo Paraguá	La Paz Beni	Pando
			(USD per head)			
Herd/truck	8.00	8.00		8.00	8.00	8.00
Rail		16.22				
Truck	36.36		25.00	52.50		52.50
Refrigerated truck					34.48	34.48
Truck to Market		5.00				
Federations	2.91	2.91	2.91	2.91	2.91	2.91
Municipal Tax	7.27	7.27	7.27	7.27	7.27	7.27
TOTAL	54.55	39.40	35.18	70.68	55.66	105.16

Costs from most regions are quoted from a central shipping point, so there is an additional charge to bring cattle from the ranch, either by herding or trucking. Only in Guarayos were quotes obtained for shipment directly from the ranch to market.

Cattle are not currently shipped from the Pando. The region has so few livestock, that it is actually a net importer, from the northern areas of the Beni. For purposes of testing the model, however, the costs of shipping beef from the region to the most accessible external market were included. Whereas lumber from the region would be shipped upriver Puerto Villaroel and by truck to Cochabamba, this route is impractical for shipping live cattle because of the time required.[4] Alternatively, cattle could be trucked during the dry season to the San Borja area in the La Paz-Beni region, slaughtered there, and the beef shipped by refrigerated truck to La Paz. These figures are the ones applied in the model.

Shrinkage is highest for the Pando and Bajo Paraguá regions which involve shipping live cattle by truck for distances of 700 kilometers over three to four days. Next are the Chiquitanía and Chaco which involve two days of shipping by rail or truck. Lowest are the Guarayos region from which live cattle are shipped easily in one day by truck, and the La Paz-Beni region where beef is slaughtered locally for shipment to La Paz.

Finally, the cattlemen's associations and municipal governments charge taxes on animals entering slaughterhouses. The figures used are typical charges, provided by the Federation of Cattlemen in Beni and Pando.

Property Taxes

Forest and cattle ranch lands are taxed differently under the 1996 reforms. Private forest lands pay the same patent per hectare as concessions, but only over the area of annual allowable cut. In other words, private forests under management plans pay only one dollar per hectare on the area harvested, rather than the entire productive forest area. With a minimum cutting cycle of 20 years, forest landowners need only pay $1 for every 20th hectare, or an average of $0.05 per hectare of forest per year.

[4] Further upriver beef is commonly shipped from the Beni plains into Puerto Villarroel and on to market in Cochabamba.

Annex Table 10. Example of Forest Land Taxation

Hectares of net productive forest	2000	hectares
Cutting cycle	20	years
Area of annual allowable cut	100	hectares
Total patent or property tax at $1.00 per hectare harvested	$100	US Dollars
Average tax per hectare of net productive forest	$0.05	US dollars per hectare

With longer cutting cycles, the tax per hectare of forest is even lower.

Cattle ranches on the other hand, are taxed according to the value declared by the owner on a progressive scale beginning at 0.35% and increasing to 1.50% of the value of land without improvements. Most ranch land in Bolivia is valued at low levels because it involves natural grasslands in remote areas. However, in places where forests have been cleared and pastures planted, declared values might be expected to range from $50 and up. The table below provides some possible scenarios that might obtain as the system comes into effect.

Annex Table 11. Examples of 1998 Property Tax Levels on Cattle Ranches

	declared	1998		
size of property	value per hectare	total value	total tax	tax per hectare
has	usd	usd	usd	usd/ha
500	50	25,000	87.50	0.18
500	100	50,000	188.78	0.38
500	150	75,000	313.78	0.63

Annex Table 12. Principal Species in Annual Allowable Cut by Region

Principal Species to be Used in the Chaco

Local Name	Scientific Name	MADEL
		(m3 of logs)
Cuchi	*Astronium urundeuva*	0.72
Curupaú	*Anadenanthera colubrina*	2.15
Cuta de Monte (Perilla)	*Phyllostylon rhamnoides*	1.07
Quebracho Colorado	*Schinopsis quebracho colorado*	0.86
Quebracho Blanco (Cacha)	*Aspidosperma quebracho blanco*	0.73
Verdolago	*Terminalia spp, or Calycophyllum multiflorum*	0.80
TOTAL AAC per hectare to be harvested		6.55
AAC per hectare of Net Productive Forest		0.19

Principal Species to be Used in the Chiquitanía

Local Name	Scientific Name	CIMAL, Velasco	CIMAL, Angel Sandoval	CICOL SUR
			(m3 of logs)	
Cuchi	*Astronium urundeuva*	1.63	2.32	1.71
Curupaú	*Anadenanthera colubrina*	1.24	0.97	3.88
Cuta de Monte (Perilla)	*Phyllostylon rhamnoides*	1.57	0.83	1.14
Jichituriqui	*Aspidosperma cylindrocarpon*	0.64	0.55	0.35
Momoqui	*Caesalpinia pluviosa*	1.15	0.59	0.66
Morado	*Machaerium scleroxylon*	0.42	1.12	0.75
Roble	*Amburana cearensis*	0.74	0.94	0.27
Sirari	*Copaifera chodatiana*	0.28	0.15	1.20
Soto	*Schinopsis brasilensis*	0.62	1.43	0.80
Tajibo	*Tabebuia sp*	0.40	0.43	0.84
Tasaá	*Acosmium cardenasii*	1.70	0.87	0.69
Verdolago	*Terminalia spp, or Calycophyllum multiflorum*	0.46	0.72	0.16
TOTAL AAC per hectare to be harvested		10.85	11.39	13.47
AAC per hectare of Net Productive Forest		0.43	0.33	0.38

Principal Species to be Used in Guarayos

Local Name	Scientific Name	LA CHONTA
		(m3 of logs)
Ajo	*Gallesia integrifolia*	0.76
Azucaró, Cedrillo	*Spondias mombin*	1.16
Bibosi	*Ficus sp.*	5.99
Blanquillo	*Ampelocera ruizii*	1.87
Coquino	*Pouteria macrophylla*	0.65
Ochoó	*Hura crepitans*	3.49
Ojoso Colorado	*Pseudolmedia laevis*	0.64
Serebó	*Schizolobium amazonicum*	0.52
Verdolago	*Terminalia spp, or Calycophyllum multiflorum*	1.91
Yesquero	*Cariniana estrellensis*	4.42
TOTAL AAC per hectare to be harvested		22.63
AAC per hectare of Net Productive Forest		0.75

Principal Species to be Used in Bajo Paraguá

Local Name	Scientific Name	TARUMÁ
		(m3 of logs)
Bibosi	*Ficus sp.*	1.76
Cambará	*Erisma Uncinatum*	7.45
Mururé	*Brosimum acutifolium*	5.16
Paquió	*Hymenaea courbaril*	0.74
Verdolago	*Terminalia spp, or Calycophyllum multiflorum*	0.78
TOTAL AAC per hectare to be harvested		17.14
AAC per hectare of Net Productive Forest		0.58

Principal Species to be Used in La Paz-Beni

Local Name	Scientific Name	YUCUMO	LA LUNA
		(m3 of logs)	
Almendrillo	*Dipteryx odorata*	3.08	6.04
Bibosi	*Ficus sp.*	1.86	0.47
Copaibo	*Copaifera reticulata*	0.55	1.11
Mapajo	*Ceiba pentandra*	0.71	2.18
Mara macho	*Cedrelinga cataeniformis*		1.74
Ochoó	*Hura crepitans*		0.81
Palo María	*Calophyllum brasiliense*	1.29	0.48
Sangre de Toro-Gabún	*Virola sebifera*	1.00	0.96
Trompillo	*Guarea macrophylla*	0.59	0.26
Verdolago	*Terminalia spp, or Calycophyllum multiflorum*	3.29	2.11
Yesquero	*Cariniana estrellensis*	0.76	
TOTAL AAC per hectare to be harvested		15.96	18.09
AAC per hectare of Net Productive Forest		0.79	0.85

Principal Species to be Used in Pando

Local Name	Scientific Name	CIMAGRO	SAN JOAQUIN
		(m3 of logs)	
Aliso	*Vochysia vismiifolia*		0.70
Almendrillo	*Dipteryx odorata*	3.40	0.43
Cedro	*Cedrela fissilis*	0.73	0.14
Cuta	*Astronium sp.*	0.10	0.58
Enchoque	*Cariniana decandra*	0.15	1.83
Isigo	*Tetragastris altissima*		0.58
Itauba	*Mezilaurus itauba*	0.51	0.10
Mara macho	*Cedrelinga cataeniformis*	0.15	1.92
Morado	*Peltogyne sp*		3.94
Tajibo	*Tabebuia sp*	0.58	0.02
Toco	*Enterolobium contortisiliquum*		1.98
Yesquero	*Cariniana estrellensis*	0.32	0.64
TOTAL AAC per hectare to be harvested		7.20	13.45
AAC per hectare of Net Productive Forest		0.36	0.59